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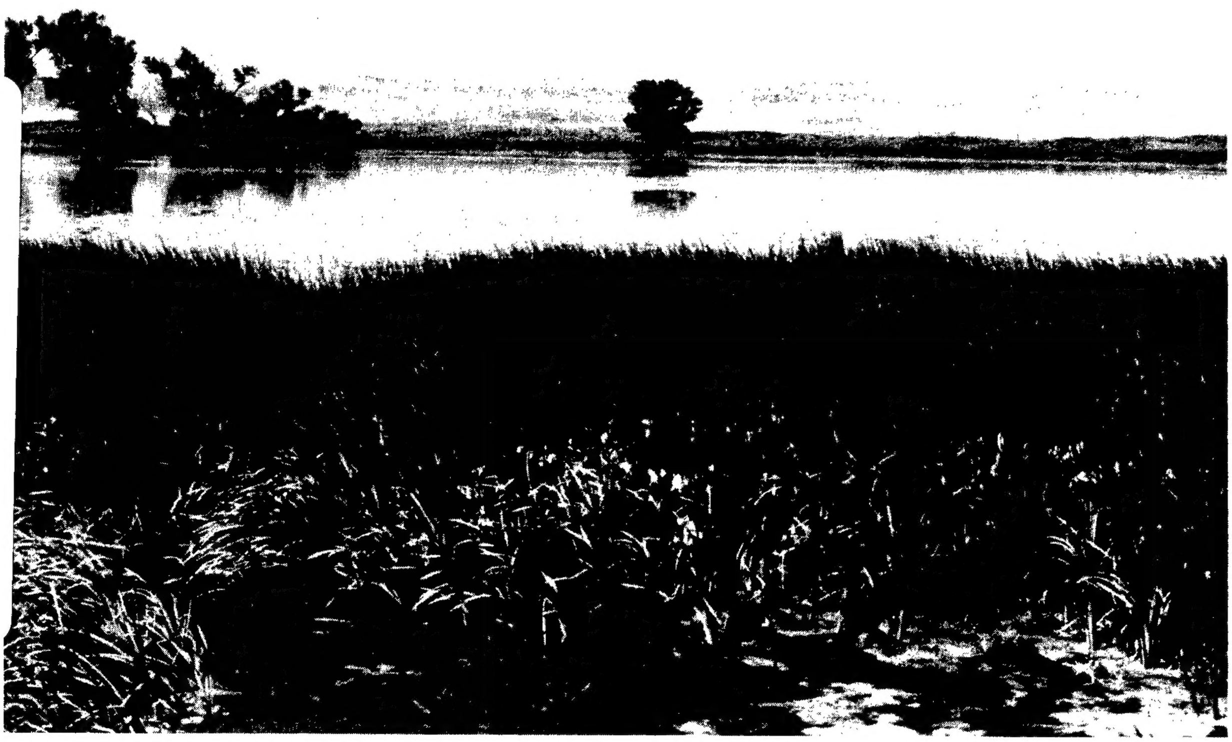

Fish and Wildlife Service

U.S. Department of the Interior

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# SOIL-VEGETATION CORRELATIONS IN THE SANDHILLS AND RAINWATER BASIN WETLANDS OF NEBRASKA

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# PREFACE

The National Ecology Center of the U.S. Fish and Wildlife Service (FWS) is supporting a series of field research studies to document relationships between hydric soils and wetland vegetation in selected wetlands throughout the United States. This study is one of that series. It is a continuation of the FWS effort, begun by Wentworth and Johnson (1986), to develop a procedure using vegetation to designate wetlands based on the indicator status of wetland vegetation as described by the FWS "National List of Plants that Occur in Wetlands" (Reed 1986a). This list classifies vascular plants of the U.S. into one of five categories according to their natural frequency of occurrence in wetlands. Concurrent with the development of the wetland plant list, the Soil Conservation Service (SCS) developed the "National List of Hydric Soils" (SCS 1985a). Studies supported by the National Ecology Center quantitatively compare associations of plant species, designated according to their hydric nature using the Wentworth and Johnson (1986) procedure, with the hydric nature of soils according to their designation on the SCS hydric soils list. The studies are being conducted across moisture gradients at a variety of wetland sites throughout the U.S. Several studies have been modified to obtain information on groundwater hydrology.

These studies were conceived in 1984 and implemented in 1985 in response to internal planning efforts of the FWS. They parallel, to some extent, ongoing efforts by the SCS to delineate wetlands for Section 1221 of the Food Security Act of 1985 (the swampbuster provision). The SCS and FWS provided joint guidance and direction in the development of the Wentworth and Johnson (1986) procedure, and the SCS currently is testing a procedure that combines hydric soils and the Wentworth and Johnson procedure for practical wetland delineation. The efforts of both agencies are complimentary and are being conducted in close cooperation.

The primary objectives of these studies are to (1) assemble a quantitative data base of wetland plant community dominance and codominance for determining the relationship between wetland plants and hydric soils; (2) test various delineation algorithms based on the indicator status of plants against independent measures of hydric character, primarily hydric soils; and (3) test, in some instances, the correlation with groundwater hydrology. The results of these studies also can be used, with little or no supplementary hydrologic information, to compare wetland delineation methods of the Corps of Engineers (1987) and the Environmental Protection Agency (Sipple 1987).

Any questions or suggestions regarding these studies should be directed to: Charles Segelquist, 2627 Redwing Road, Creekside One Building, Fort Collins, Colorado, 80526-2899, phone FTS 323-5384 or Commercial (303) 226-9384.

CONTENTS

TABLES

ACKNOWLEDGMENTS

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# INTRODUCTION

Wetlands are defined by the U.S. Fish and Wildlife Service as lands that are

> ... transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.... Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.... The upland limit of a wetland is designated as: (1) the boundary between land with predominantly mesophytic and xerophytic cover; (2) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or (3) in the case of wetlands without vegetation or soil, the boundary between land that is flooded or saturated at some time each year and land that is not (Cowardin et al. 1979:3-4).

Wetland systems across the United States are threatened by human impacts. Agricultural conversions, urban encroachment, and other habitat modifications have decreased wetland acreage. Only 45% of the original wetland acreage in the United States remained in the mid-1970's (Tiner and Wilen 1983).

With past and continued losses of natural wetlands and increased socioeconomic interests in wetlands, the importance of remaining wetlands has increased. Wetland and deepwater ecosystems provide fish and wildlife habitats, flood control, water quality maintenance, ecosystem integrity, and socioeconomic benefits. The ability to delineate wetlands therefore becomes essential for agencies charged with their management and protection, such as the U.S. Fish and Wildlife Service.

The Cowardin et al. (1979) classification system defines wetland systems by vegetation, soils, and water regime within a given area. Hydrophytic vegetation is defined as plants that grow in water or a substrate that is at least periodically deficient in oxygen during a growing season as a result of excessive water content (Soil Conservation Service 1986a). Hydric soils are defined as soils that in an undrained condition are saturated, flooded, or inundated long enough during the growing season to develop anaerobic conditions, which favor the growth and regeneration of hydrophytic vegetation (Soil Conservation Service 1985a).

Correlations between vegetation and soil parameters provide essential guidelines for delineation and management of important wetland types throughout the United States. The U.S. Fish and Wildlife Service (Reed 1986a) has compiled a list of wetland plants (hydrophytes) and the Soil Conservation Service (1985a) has compiled a list of hydric soils to facilitate wetland delineation. Methodologies developed by Wentworth and Johnson (1986) for delineating wetlands solely by vegetation were used to determine whether hydric soils identified by the Soil Conservation Service in Nebraska (1985b) support predominantly wetland plants as identified by the U.S. Fish and Wildlife Service (Reed 1986a, 1986b).

The Rainwater Basin and Sandhills regions in Nebraska were selected for a wetland vegetation-hydric soil correlation study as part of a National study by the National Ecology Center of the U.S. Fish and Wildlife Service. The primary objectives of our study were (1) to assemble a quantitative data base for determining relationships between the U.S. Fish and Wildlife Service National Wetland Plant List (Reed 1986b) and the Soil Conservation Service (1985b) Hydric Soils List, (2) to estimate the extent to which hydric soils supported a prevalence of wetland vegetation as identified by the indicator status of plants recorded on the wetland plant list, and (3) to test Wentworth and Johnson (1986) and other wetland delineation methodologies as they pertain to soil-vegetation correlations.

## DESCRIPTION OF STUDY AREAS

This study was performed at wetlands in the Rainwater Basin and Sandhills regions of Nebraska. Four areas were selected for the study: adjacent Clay and Fillmore counties in the eastern Rainwater Basin, Rock County in the northeast Sandhills region, Valentine National Wildlife Refuge in the north-central Sandhills region, and Crescent Lake National Wildlife Refuge in the southwest Sandhills region (Figure 1).

### RAINWATER BASIN

The Rainwater Basin encompasses a drainage area in south-central Nebraska south of the Platte River that includes portions of 17 counties. The basin covers approximately 6,720 $km^2$ (Environmental Protection Agency 1986) and was formed from windblown silt deposits. Sink-like depressions occur throughout the terrain, and water accumulations have leached and concentrated clay particles in the subsoils, forming a 0.1-2 m clay layer impervious to water (U.S. Fish and Wildlife Service 1985a). Wetlands that are located in depressions rely heavily on surface runoff and natural rainfall for water; therefore, wetland dynamics within the Rainwater Basin are influenced greatly by hydrologic events.

Climate in Clay and Fillmore counties, Nebraska, is characterized by cold winters and hot summers. Mean total annual precipitation in Clay and Fillmore counties is 69.9 cm; heaviest rainfalls occur in late spring and early summer (Hammer et al. 1981, 1986). Precipitation was below normal in these counties during our field season (T. Hupf, U.S. Fish and Wildlife Service, Grand Island, NE; pers. comm.).

During presettlement times, the Rainwater Basin contained nearly 4,000 wetlands, covering an area of approximately 38,000 ha. By 1981, less than 10% of the original wetlands remained, due to agricultural conversions (Farrar 1982). Of the remaining wetlands, only 49% are under State or Federal protection (U.S. Fish and Wildlife Service 1985a). Wetlands of the Rainwater Basin provide spring staging areas for 5-7 million waterfowl/year in the Central Flyway (Environmental Protection Agency 1986); nearly all of the midcontinental population of 300,000 white-fronted geese (<u>Anser albifrons</u>) stage in the basin each year (U.S. Fish and Wildlife Service 1985a).

Six Federal Waterfowl Production Areas were chosen for our study in the Rainwater Basin. Although these areas are managed for waterfowl, sample sites with minimal vegetation modification were selected when possible (Table 1).

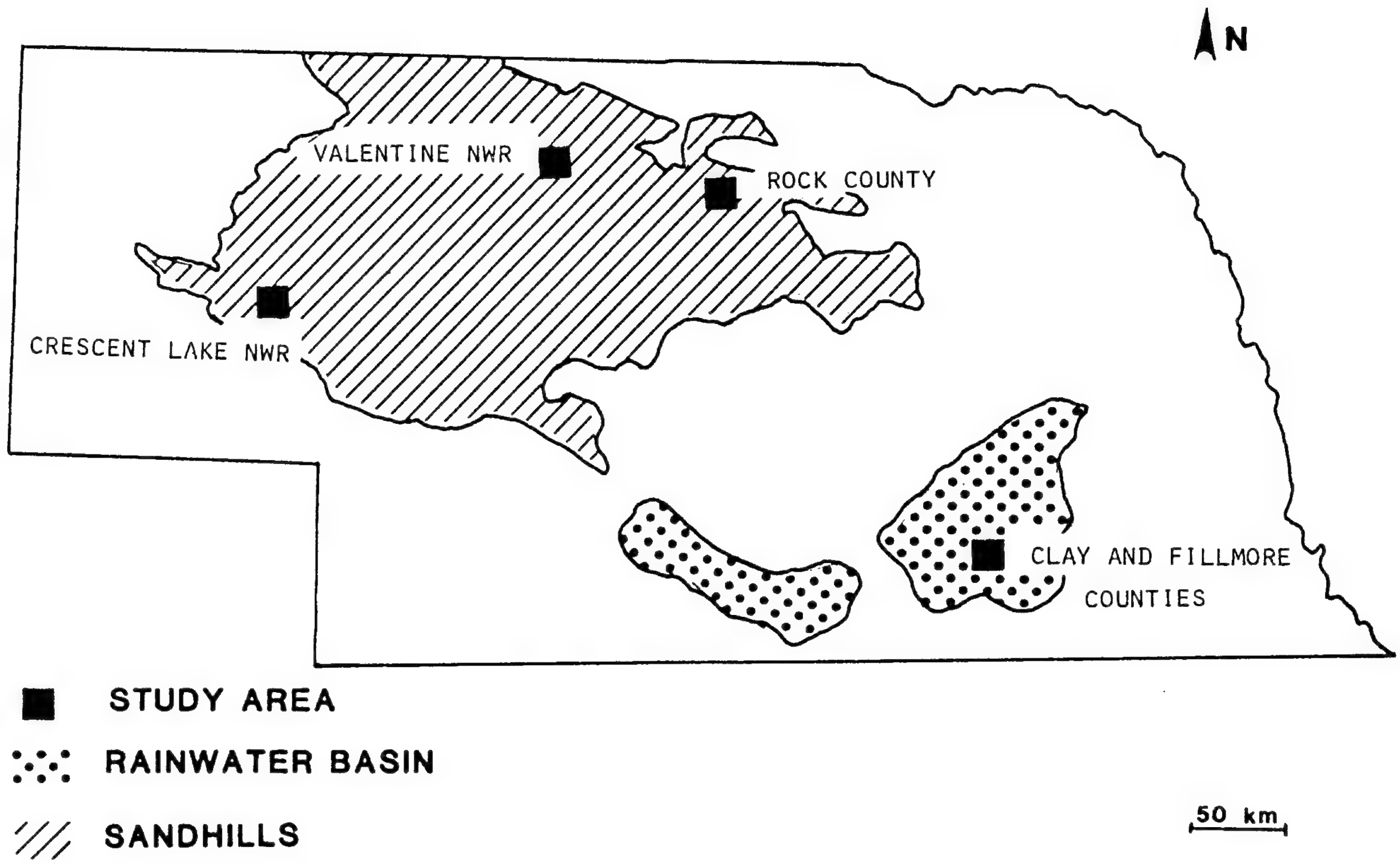


Figure 1. Rainwater Basin and Sandhills regions of Nebraska, with location of study areas.

## THE SANDHILLS

The Sandhills region is the largest continuous sand dune formation in the western hemisphere, encompassing approximately 32,000 $km^2$. This region presumably was formed by wind action on late Tertiary and early Pleistocene deposits (McCarraher 1970). Soils of the Sandhills are highly erodible, and soil "blowouts" occur frequently where vegetative cover is insufficient. At the turn of the century, Rydberg (1895) documented blowouts 100 m in diameter and 15-20 m deep. Climate in the Sandhills is semiarid, with mean annual precipitation ranging from 63.5 cm in the east to 37.6 cm in the west (Rundquist 1983). Rock County receives 55.9 cm mean annual precipitation, with 75% occurring between April and September (Zink et al. 1985); precipitation in the county apparently was normal at the time of our study. Valentine Natonal Wildlife Refuge was experiencing a wet spring at the time of our study, whereas conditions were drier than normal at Crescent Lake National Wildlife Refuge.

The Sandhills contain approximately 557,590 ha of wetlands (Rundquist et al. 1981). Over 11,340 ha of wetlands, or 15% of the original wetland acreage, were lost from the Sandhills region prior to the 1970's (Nebraska Game and Parks Commission 1972). Wetland acreage losses as of 1986 may be in excess of 30% for the entire Sandhills region, including estimated habitat losses of 92% in Loup County alone (D. Gersib, Nebraska Game and Parks Commission, Lincoln, NE; pers. comm.). Center-pivot irrigation, with associated ditching, levelling, filling of wetlands, and groundwater depletion, is the major cause of wetland habitat destruction in the Sandhills (T. Taylor, U.S. Fish and Wildlife Service, Grand Island, NE; pers. comm.); use of center-pivots in the Sandhills has increased 1,746% since 1972 (U.S. Fish and Wildlife Service 1981). The localized ground water table northwest of Alliance, Nebraska has been depleted 10 m since 1946 (Conservation and Survey Division 1986); a reduction of only 1 m can alter acreage and type of a Sandhill wetland (Soil Conservation Service 1986b).

Despite habitat losses, Sandhill wetlands provide nesting and migration sites for millions of waterfowl, songbirds, and shorebirds (Wolfe 1984), as well as habitats for fish and terrestrial wildlife (Rundquist 1983; U.S. Fish and Wildlife Service 1985b). The Sandhills were listed as one of 34 geographic areas of concern in the North American Waterfowl Management Plan adopted by the United States and Canada in 1985, and are considered by the Nebraska Game and Parks Commission to be the most important waterfowl production area in the State (D. Gersib, pers. comm.).

Wetlands in our study were located in three areas of the Sandhills (Figure 1): Rock County (263,600 ha); Valentine National Wildlife Refuge (28,960 ha), Cherry County; and Crescent Lake National Wildlife Refuge (18,630 ha), Garden County. Vegetation in the wetlands sampled was in an undisturbed condition, unless otherwise noted (Table 1). Vegetation associations often included introduced exotics, but were relatively free from grazing, crop production, and human impact. Modified wetlands were included in our study only when a soil series was not dispersed widely throughout the study area.

Table 1. Wetlands and soil series sampled, with land use practices.

| Wetland | Date | Soil series | Land use[a] |
|---|---|---|---|
| | RAINWATER BASIN | | |
| McMurtrey WPA[b] | 6/5/86 | Massie, Scott, Butler | tilling in Butler |
| | 6/6/86 | Scott, Butler | |
| Massie WPA | 6/6/86 | Massie, Scott, Butler | |
| Hansen WPA | 6/7/86 | Massie, Fillmore, Scott, Butler | |
| Mallard Haven WPA | 6/7/86 | Massie, Fillmore, Scott, Butler | |
| Rolland WPA | 6/7/86 | Fillmore | cattle grazing |
| Lange WPA | 6/7/86 | Fillmore | |
| | ROCK COUNTY | | |
| Peterson Lake | 6/13/86 | Marlake, Tryon | |
| Linke Lake | 6/14/86 | Marlake, Loup | |
| Adams Lake | 6/14/86 | Loup | cattle grazing |
| Fish Lake | 6/16/86 | Marlake, Loup, Tryon | |
| South Twin Lake | 6/18/86 | Tryon | |
| Smith Lake | 6/18/86 | Marlake, Loup, Tryon | |
| | VALENTINE NATIONAL WILDLIFE REFUGE | | |
| Tom's Lake | 6/26/86 | Marlake, Tryon., Els | |
| "21" Lake | 6/27/86 | Marlake, Tryon, Ipage | |
| Center Lake | 6/27/86 | Marlake, Tryon, Els | |
| | 7/2/86 | Els | |
| Calf Camp Marsh | 6/29/86 | Marlake, Tryon | |
| | 7/2/86 | Els | |
| | CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | |
| Martin Lake | 7/8/86 | Marlake, Els | |
| Section 30E Marsh | 7/8/86 | Marlake, Hoffland, Els | |
| Perrin Lake | 7/8/86 | Marlake, Hoffland, Els | drawdown |
| Goose Lake | 7/9/86 | Marlake, Hoffland, Loup, Valentine | |
| Island Lake | 7/10/86 | Marlake, Tryon | cattle grazing |
| | 7/11/86 | Marlake, Els | |
| Roundup Lake | 7/11/86 | Marlake, Tryon, Valentine | |
| Gimlet Lake | 7/12/86 | Marlake, Loup, Els | |

[a]Represents known land use practices at the time of our study; unless otherwise designated, areas were in ungrazed vegetation.
[b]WPA: Federal Waterfowl Production Area

Most wetlands in Rock County were located near pivot irrigation sites; depletion of ground water by pivot farming may have altered the original plant community, although effects of pivots on vegetation composition cannot be estimated from our study. Wetlands sampled at Valentine National Wildlife Refuge have been grazed and hayed in past years, but not at the time of our study. Several wetlands in Crescent Lake National Wildlife Refuge were equipped with water control structures (only one site was in drawdown condition at the time of our study), and Island Lake showed evidence of recent grazing (Table 1).

## METHODS

Known hydric and nonhydric soils were identified from the Hydric Soils List of Nebraska (Soil Conservation Service 1985b). Ideally, all known hydric and at least one nonhydric soil series were sampled; descriptions of these series are given in Appendix A. At least four wetlands were chosen within each study area where selected soils were represented. Additional wetlands were selected if all soil series were not present in a given wetland, such that four replicates existed for each soil series sampled.

Field work was conducted from 5 June - 12 July 1986. Recent (post-1980) soil survey maps were available for Clay and Fillmore counties in the Rainwater Basin, Rock County, and Crescent Lake National Wildlife Refuge in Garden County. Soils in Valentine National Wildlife Refuge had not been mapped since the mid-1950's; Dave Hoover and Roger Hammer (Soil Survey Office, Valentine, NE) were contacted to ground-truth soils along established transects at selected wetlands.

Sampling sites were located randomly on soil survey maps (when available). Within a given soil series, vegetation in the study plots was separated into four strata: trees, tall shrubs, short shrubs, and ground cover layers (Table 2). Centers of 100 $m^2$ study plots were established randomly in a soil series at approximately 10-30 m intervals, so they did not overlap. Quadrats in each of 5-100 $m^2$ study plots/soil series vegetation strata were established randomly; paired ground cover plots were established by blindly tossing a 0.5 $m^2$ quadrat sampler. Qualitative field estimates of soil moisture content were recorded for each study plot (see legend of Appendix B for description).

Plant species were assigned ecological indices from the Wetland Plant List for the South Plains Region (Reed 1986b), based on frequencies of occurrence in wetlands (Table 3). Species not listed were assigned the most conservative, appropriate modifiers; for example, *Bromus inermis* was not listed, but we designated it as "facultative upland" because this was the most conservative modifier listed for the genus *Bromus* (Reed 1986a). Individuals that could not be identified to the species level due to advanced phenology were denoted by "spp." and were assigned the driest modifier listed for the genus; all individuals classified only to genus were analyzed together.

Weighted averages for each vegetation strata were calculated for each soil series and individual wetlands within a soil series in a study area. The equation used was adopted from Wentworth and Johnson (1986):

Table 2. Sampling schemes for vegetation strata.

| Strata and definition | Variables measured | Size of quadrats | Replications per soil series |
|---|---|---|---|
| Trees: all stems $\geq$ 7.5 cm dbh | Density: dbh (cm) all stems | 100 $m^2$ | 5 |
| Tall Shrubs: woody species < 7.5 cm dbh, $\geq$ 1.3 m tall | Density: count all main leaders | 4 $m^2$ | 5 |
| Short Shrubs: woody species < 1.3 m, $\geq$ 0.5 m | Density: count all individual plants emerging from ground | 4 $m^2$ | 5 |
| Ground Cover: woody species < 0.5 m and all herbaceous species regardless of height | percent cover in 0-6 Daubenmire (1968) classes[a] | 0.5 $m^2$ | 10 |

[a]Daubenmire classes are listed in Table 4.

Table 3. Ecological indices used for weighted, presence/absence, and Michener averages, with definitions of modifiers in the Wetland Plant List, South Plains region.

| Modifier | Ecological indices[a] | | | Definition |
|---|---|---|---|---|
| | $W_j$ | $P_j$ | $M_j$ | |
| Obligate | 1 | 1 | 1 | species always occurring in wetlands (frequency > 99%) |
| Facultative wet and fac. wet drawdown[b] | 2 | 2 | .82 | species usually occurring in wetlands (67%-99% frequency) |
| Facultative and fac. drawdown | 3 | 3 | .50 | species sometimes occurring in wetlands (34%-66% frequency) |
| Facultative upland and fac. upland drawdown | 4 | 4 | .18 | species seldom occurring in wetlands (1%-33% frequency) |
| Upland and upland drawdown | 5 | 5 | 0 | species occurring in wetlands with less than 1% frequency; also includes all species not assigned one of the above modifiers |

[a] $W_j$ = weighted average (Wentworth and Johnson 1986)
$P_j$ = presence/absence average
$M_j$ = Michener average (Michener 1983)
[b] Drawdown: indicates species favored by drawdown conditions.

$$W_j = \left( \sum_{i=1}^{n} I_{ij} \cdot E_i \right) / \left( \sum_{i=1}^{n} I_{ij} \right),$$

where $W_j$ = weighted average for stand j, $I_{ij}$ = importance value for species i in stand j, $E_i$ = ecological index for species i, and n = number of species in stand j. Importance values corresponded to Daubenmire (1968) cover classes defined in Table 4. The ecological index for each species corresponded to modifiers recorded in the Wetland Plant List (Table 3).

Modified equations were used to calculate presence/absence averages ($P_j$), referred to as index averaging by Wentworth and Johnson (1986), and Michener (1983) averages ($M_j$) for each soil series and wetland within a soil series. To calculate $P_j$, the parameter $I_{ij}$ was assigned a value of 1 when a species was present or 0 when absent. Weighted ecological indices used in Michener averages are listed in Table 3.

Range, mean, standard deviation, and standard error of mean values were calculated for ecological indices of vegetation based on weighted averages, presence/absence averages, and Michener averages by soil series and individual wetlands within each soil series. Averages for soil series were analyzed using Analysis of Variance and Duncan's multiple range tests. Identical analyses were used to make comparisons between weighted and presence/absence averages for soil series. Contrasts with Michener averages were not made because calculated values were not comparable. Ecological indices for vegetation based on weighted averages and presence/absence averages less than 3.00 (Wentworth and Johnson 1986) or Michener (1983) averages greater than 0.50 are considered indicators of wetland conditions.

Table 4. Importance values assigned to ground cover stratum (Daubenmire 1968).

| Importance value | Definition |
|---|---|
| 1 | Percent ground cover of 0.1-5 |
| 2 | Percent ground cover of 6-25 |
| 3 | Percent ground cover of 26-50 |
| 4 | Percent ground cover of 51-75 |
| 5 | Percent ground cover of 76-95 |
| 6 | Percent ground cover of 96-100 |

## RESULTS

Of the 224 species identified in this study (Appendix B), 214 were sampled in the ground cover stratum: 64 from the Rainwater Basin and 194 from the Sandhills (Rock County, 92 species; Valentine National Wildlife Refuge, 89 species; Crescent Lake National Wildlife Refuge, 132 species). Tree and shrub strata composed very little of the vegetation; 4 tree species and 2 shrub species (Ulmus americana occurred in both strata) were associated with plots in the Rainwater Basin, compared to no trees and 5 shrub species in the Sandhills.

Only ground cover data were analyzed, because other vegetational strata were not represented sufficiently at the study areas. Means, standard errors of means, and ranges were calculated for weighted averages, presence/absence averages, and Michener averages for soil series and wetland sites in each study area (Tables 5, 6, and 7). Cover values for unknown species were not included in these quantitative analyses.

Duncan's multiple range tests were performed on ecological indices for weighted averages, presence/absence averages, and Michener averages for soil series (Tables 8, 9, and 10, respectively). Values in the same letter grouping are not statistically different. Vegetation is considered to be wetland or hydric when weighted averages and presence/absence averages are less than 3.00 or Michener averages are greater than 0.50; hydric soils as identified by the Soil Conservation Service (1985b) are indicated by asterisks (*). Duncan's multiple range tests for comparisons between weighted and presence/absence averages revealed that these values were not statistically different for any given soil series (Table 11). Because ecological indices were weighted differently in Michener averages (Table 3), they were not comparable statistically to the other averages. Frequencies of occurrence of species were determined for individual soil series within study areas (Appendix C).

Prevalence of hydrophytic vegetation determinations from weighted and presence/absence averages corresponded to the Hydric Soils List for all soil series except one. Discrepencies existed within the Tryon series, a hydric soil, among geographic locations. At Rock County and Valentine National Wildlife Refuge, both weighted and presence/absence averages indicated that Tryon supported a prevalence of hydrophytic vegetation, whereas the calculated value was greater than 3.00 at Crescent Lake National Wildlife Refuge, indicating that a prevalence of hydrophytic vegetation did not occur (Table 11). The Butler series, a suspected hydric soil not included in the SCS list, did not support a prevalence of wetland vegetation as indicated by either methods of calculation (Table 11).

Table 5. Means, standard errors of means, and ranges for weighted averages by soil series and wetlands.

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| RAINWATER BASIN | | | | |
| *Massie | 40 | 1.413 | 0.080 | 2.000 |
| McMurtrey WPA | 10 | 1.707 | 0.263 | 2.000 |
| Massie WPA | 10 | 1.129 | 0.086 | 0.667 |
| Hansen WPA | 10 | 1.303 | 0.073 | 0.667 |
| Mallard Haven WPA | 10 | 1.513 | 0.089 | 1.000 |
| *Fillmore | 40 | 2.445 | 0.082 | 1.905 |
| Hansen WPA | 10 | 2.834 | 0.077 | 0.800 |
| Mallard Haven WPA | 10 | 2.873 | 0.102 | 1.111 |
| Rolland WPA | 10 | 2.195 | 0.116 | 1.141 |
| Lange WPA | 10 | 1.878 | 0.092 | 0.871 |
| *Scott | 39 | 2.855 | 0.107 | 3.000 |
| McMurtrey WPA | 10 | 2.460 | 0.285 | 2.333 |
| Massie WPA | 10 | 2.984 | 0.181 | 1.700 |
| Hansen WPA | 10 | 3.218 | 0.176 | 1.455 |
| Mallard Haven WPA | 9 | 2.748 | 0.111 | 1.000 |
| Butler | 38 | 3.221 | 0.109 | 3.000 |
| McMurtrey WPA | 10 | 2.959 | 0.341 | 3.000 |
| Massie WPA | 10 | 3.283 | 0.091 | 0.800 |
| Hansen WPA | 8 | 3.013 | 0.123 | 1.107 |
| Mallard Haven WPA | 10 | 3.589 | 0.158 | 1.455 |
| ROCK COUNTY | | | | |
| *Marlake | 40 | 1.280 | 0.050 | 1.100 |
| Peterson Lake | 10 | 1.437 | 0.130 | 1.100 |
| Linke Lake | 10 | 1.059 | 0.025 | 0.200 |
| Fish Lake | 10 | 1.445 | 0.091 | 0.923 |
| Smith Lake | 10 | 1.181 | 0.075 | 0.714 |

(Continued)

Table 5. (Continued).

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| *Loup | 40 | 2.278 | 0.080 | 2.028 |
| Linke Lake | 10 | 2.667 | 0.093 | 0.917 |
| Adams Lake | 10 | 2.440 | 0.121 | 1.052 |
| Fish Lake | 10 | 2.085 | 0.205 | 1.878 |
| Smith Lake | 10 | 1.919 | 0.090 | 0.918 |
| *Tryon | 40 | 2.474 | 0.136 | 2.667 |
| Peterson Lake | 10 | 2.155 | 0.095 | 0.967 |
| Fish Lake | 10 | 1.589 | 0.087 | 0.917 |
| South Twin Lake | 10 | 3.795 | 0.067 | 0.571 |
| Smith Lake | 10 | 2.356 | 0.076 | 0.750 |
| VALENTINE NATIONAL WILDLIFE REFUGE | | | | |
| *Marlake | 40 | 1.257 | 0.025 | 0.667 |
| Tom's Lake | 10 | 1.299 | 0.023 | 0.206 |
| "21" Lake | 10 | 1.290 | 0.035 | 0.357 |
| Center Lake | 10 | 1.232 | 0.066 | 0.667 |
| Calf Camp Marsh | 10 | 1.207 | 0.065 | 0.571 |
| *Tryon | 40 | 2.532 | 0.110 | 2.624 |
| Tom's Lake | 10 | 2.746 | 0.225 | 2.141 |
| "21" Lake | 10 | 2.674 | 0.181 | 1.762 |
| Center Lake | 10 | 2.701 | 0.223 | 2.346 |
| Calf Camp Marsh | 10 | 2.007 | 0.184 | 1.917 |
| Els | 30 | 3.235 | 0.080 | 1.800 |
| Tom's Lake | 10 | 3.583 | 0.094 | 1.077 |
| Center Lake | 10 | 2.869 | 0.092 | 0.875 |
| Calf Camp Marsh | 10 | 3.253 | 0.125 | 1.400 |
| Ipage | 10 | 3.339 | 0.103 | 1.011 |
| "21" Lake | 10 | 3.339 | 0.103 | 1.011 |

(Continued)

Table 5. (Concluded).

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | | | |
| *Marlake | 109 | 1.584 | 0.036 | 1.600 |
| Martin Lake | 10 | 1.198 | 0.061 | 0.571 |
| Section 30E Marsh | 10 | 1.496 | 0.096 | 1.000 |
| Perrin Lake | 10 | 1.750 | 0.171 | 1.500 |
| Goose Lake | 19 | 1.596 | 0.071 | 1.119 |
| Island Lake | 20 | 1.758 | 0.103 | 1.457 |
| Roundup Lake | 20 | 1.439 | 0.063 | 1.111 |
| Gimlet Lake | 20 | 1.700 | 0.048 | 0.889 |
| *Hoffland | 40 | 2.471 | 0.082 | 2.286 |
| Section 30E Marsh | 20 | 2.552 | 0.118 | 1.762 |
| Perrin Lake | 10 | 2.398 | 0.212 | 2.190 |
| Goose Lake | 10 | 2.382 | 0.095 | 0.985 |
| *Loup | 40 | 2.399 | 0.063 | 1.536 |
| Goose Lake | 20 | 2.467 | 0.088 | 1.432 |
| Gimlet Lake | 20 | 2.331 | 0.089 | 1.286 |
| *Tryon | 40 | 3.308 | 0.090 | 2.167 |
| Island Lake | 20 | 3.694 | 0.058 | 0.750 |
| Roundup Lake | 20 | 2.923 | 0.119 | 1.738 |
| Els | 70 | 3.827 | 0.070 | 3.000 |
| Martin Lake | 10 | 3.594 | 0.171 | 1.433 |
| Section 30E Marsh | 10 | 3.990 | 0.091 | 0.889 |
| Perrin Lake | 10 | 2.854 | 0.179 | 1.667 |
| Island Lake | 20 | 4.148 | 0.097 | 2.000 |
| Gimlet Lake | 20 | 4.025 | 0.051 | 1.000 |
| Valentine | 40 | 4.263 | 0.053 | 1.250 |
| Goose Lake | 20 | 4.087 | 0.043 | 0.850 |
| Roundup Lake | 20 | 4.443 | 0.080 | 1.200 |

[a]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).

Table 6. Means, standard errors of means, and ranges for presence/absence averages by soil series and wetlands.

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| | | RAINWATER BASIN | | |
| *Massie | 40 | 1.427 | 0.079 | 1.800 |
| McMurtrey WPA | 10 | 1.691 | 0.239 | 1.800 |
| Massie WPA | 10 | 1.203 | 0.138 | 1.200 |
| Hansen WPA | 10 | 1.358 | 0.104 | 1.000 |
| Mallard Haven WPA | 10 | 1.453 | 0.081 | 1.000 |
| *Fillmore | 40 | 2.466 | 0.080 | 1.867 |
| Hansen WPA | 10 | 2.830 | 0.080 | 0.771 |
| Mallard Haven WPA | 10 | 2.845 | 0.097 | 0.950 |
| Rolland WPA | 10 | 2.312 | 0.094 | 0.917 |
| Lange WPA | 10 | 1.877 | 0.114 | 1.067 |
| *Scott | 39 | 2.836 | 0.106 | 3.000 |
| McMurtrey WPA | 10 | 2.308 | 0.257 | 2.333 |
| Massie WPA | 10 | 3.030 | 0.134 | 1.225 |
| Hansen WPA | 10 | 3.197 | 0.191 | 1.714 |
| Mallard Haven WPA | 9 | 2.805 | 0.130 | 1.250 |
| Butler | 38 | 3.229 | 0.108 | 3.000 |
| McMurtrey WPA | 10 | 2.889 | 0.335 | 3.000 |
| Massie WPA | 10 | 3.334 | 0.119 | 1.000 |
| Hansen WPA | 8 | 3.059 | 0.109 | 0.944 |
| Mallard Haven WPA | 10 | 3.599 | 0.132 | 1.167 |
| | | ROCK COUNTY | | |
| *Marlake | 40 | 1.309 | 0.060 | 1.600 |
| Peterson Lake | 10 | 1.518 | 0.176 | 1.600 |
| Linke Lake | 10 | 1.088 | 0.040 | 0.333 |
| Fish Lake | 10 | 1.465 | 0.087 | 0.750 |
| Smith Lake | 10 | 1.167 | 0.079 | 0.800 |

(Continued)

Table 6. (Continued).

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| *Loup | 40 | 2.354 | 0.084 | 2.175 |
| Linke Lake | 10 | 2.733 | 0.101 | 1.089 |
| Adams Lake | 10 | 2.593 | 0.094 | 1.107 |
| Fish Lake | 10 | 2.120 | 0.119 | 1.943 |
| Smith Lake | 10 | 1.970 | 0.136 | 1.125 |
| *Tryon | 40 | 2.491 | 0.132 | 2.750 |
| Peterson Lake | 10 | 2.144 | 0.081 | 0.944 |
| Fish Lake | 10 | 1.594 | 0.099 | 1.000 |
| South Twin Lake | 10 | 3.738 | 0.087 | 0.727 |
| Smith Lake | 10 | 2.489 | 0.066 | 0.689 |
| VALENTINE NATIONAL WILDLIFE REFUGE | | | | |
| *Marlake | 40 | 1.264 | 0.025 | 0.600 |
| Tom's Lake | 10 | 1.330 | 0.028 | 0.250 |
| "21" Lake | 10 | 1.240 | 0.026 | 0.167 |
| Center Lake | 10 | 1.233 | 0.051 | 0.500 |
| Calf Camp Marsh | 10 | 1.254 | 0.076 | 0.600 |
| *Tryon | 40 | 2.516 | 0.100 | 2.657 |
| Tom's Lake | 10 | 2.689 | 0.210 | 2.094 |
| "21" Lake | 10 | 2.608 | 0.152 | 1.472 |
| Center Lake | 10 | 2.742 | 0.197 | 2.190 |
| Calf Camp Marsh | 10 | 2.023 | 0.169 | 1.625 |
| Els | 30 | 3.158 | 0.076 | 1.571 |
| Tom's Lake | 10 | 3.499 | 0.113 | 1.182 |
| Center Lake | 10 | 2.819 | 0.082 | 0.756 |
| Calf Camp Marsh | 10 | 3.156 | 0.101 | 1.000 |
| Ipage | 10 | 3.290 | 0.082 | 0.792 |
| "21" Lake | 10 | 3.290 | 0.082 | 0.792 |

(Continued)

Table 6. (Concluded).

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | | | |
| *Marlake | 109 | 1.662 | 0.042 | 2.000 |
| Martin Lake | 10 | 1.293 | 0.060 | 0.600 |
| Section 30E Marsh | 10 | 1.525 | 0.099 | 1.000 |
| Perrin Lake | 10 | 2.100 | 0.245 | 2.000 |
| Goose Lake | 19 | 1.599 | 0.072 | 1.133 |
| Island Lake | 20 | 1.843 | 0.110 | 1.400 |
| Roundup Lake | 20 | 1.476 | 0.067 | 1.333 |
| Gimlet Lake | 20 | 1.762 | 0.046 | 0.857 |
| *Hoffland | 40 | 2.490 | 0.084 | 2.250 |
| Section 30E Marsh | 20 | 2.601 | 0.129 | 2.000 |
| Perrin Lake | 10 | 2.368 | 0.187 | 2.250 |
| Goose Lake | 10 | 2.389 | 0.108 | 1.056 |
| *Loup | 40 | 2.411 | 0.062 | 1.286 |
| Goose Lake | 20 | 2.433 | 0.079 | 1.125 |
| Gimlet Lake | 20 | 2.388 | 0.096 | 1.286 |
| *Tryon | 40 | 3.306 | 0.087 | 2.250 |
| Island Lake | 20 | 3.643 | 0.066 | 0.857 |
| Roundup Lake | 20 | 2.968 | 0.122 | 2.000 |
| Els | 70 | 3.808 | 0.074 | 3.000 |
| Martin Lake | 10 | 3.450 | 0.196 | 1.650 |
| Section 30E Marsh | 10 | 3.962 | 0.109 | 0.917 |
| Perrin Lake | 10 | 2.795 | 0.172 | 1.750 |
| Island Lake | 20 | 4.214 | 0.082 | 1.500 |
| Gimlet Lake | 20 | 4.013 | 0.044 | 0.832 |
| Valentine | 40 | 4.207 | 0.055 | 1.286 |
| Goose Lake | 20 | 4.086 | 0.043 | 0.786 |
| Roundup Lake | 20 | 4.328 | 0.094 | 1.250 |

[a]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).

Table 7. Means, standard errors of means, and ranges for Michener averages by soil series and wetlands.

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| | | RAINWATER BASIN | | |
| *Massie | 40 | 0.907 | 0.020 | 0.523 |
| McMurtrey WPA | 10 | 0.818 | 0.068 | 0.523 |
| Massie WPA | 10 | 0.965 | 0.023 | 0.182 |
| Hansen WPA | 10 | 0.936 | 0.018 | 0.167 |
| Mallard Haven WPA | 10 | 0.908 | 0.016 | 0.180 |
| *Fillmore | 40 | 0.639 | 0.023 | 0.504 |
| Hansen WPA | 10 | 0.525 | 0.020 | 0.187 |
| Mallard Haven WPA | 10 | 0.533 | 0.031 | 0.324 |
| Rolland WPA | 10 | 0.699 | 0.033 | 0.328 |
| Lange WPA | 10 | 0.797 | 0.028 | 0.243 |
| *Scott | 39 | 0.522 | 0.030 | 0.820 |
| McMurtrey WPA | 10 | 0.629 | 0.075 | 0.607 |
| Massie WPA | 10 | 0.475 | 0.049 | 0.464 |
| Hansen WPA | 10 | 0.418 | 0.052 | 0.427 |
| Mallard Haven WPA | 9 | 0.571 | 0.033 | 0.299 |
| Butler | 38 | 0.415 | 0.030 | 0.820 |
| McMurtrey WPA | 10 | 0.483 | 0.092 | 0.820 |
| Massie WPA | 10 | 0.399 | 0.025 | 0.228 |
| Hansen WPA | 8 | 0.489 | 0.034 | 0.302 |
| Mallard Haven WPA | 10 | 0.302 | 0.046 | 0.427 |
| | | ROCK COUNTY | | |
| *Marlake | 40 | 0.933 | 0.013 | 0.296 |
| Peterson Lake | 10 | 0.897 | 0.033 | 0.296 |
| Linke Lake | 10 | 0.989 | 0.005 | 0.036 |
| Fish Lake | 10 | 0.884 | 0.025 | 0.252 |
| Smith Lake | 10 | 0.963 | 0.017 | 0.169 |

(Continued)

Table 7. (Continued).

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| *Loup | 40 | 0.677 | 0.022 | 0.546 |
| Linke Lake | 10 | 0.583 | 0.026 | 0.258 |
| Adams Lake | 10 | 0.628 | 0.035 | 0.313 |
| Fish Lake | 10 | 0.724 | 0.056 | 0.520 |
| Smith Lake | 10 | 0.771 | 0.025 | 0.254 |
| *Tryon | 40 | 0.624 | 0.039 | 0.760 |
| Peterson Lake | 10 | 0.722 | 0.026 | 0.256 |
| Fish Lake | 10 | 0.877 | 0.027 | 0.270 |
| South Twin Lake | 10 | 0.242 | 0.020 | 0.163 |
| Smith Lake | 10 | 0.656 | 0.019 | 0.181 |
| VALENTINE NATIONAL WILDLIFE REFUGE | | | | |
| *Marlake | 40 | 0.951 | 0.005 | 0.133 |
| Tom's Lake | 10 | 0.946 | 0.004 | 0.037 |
| "21" Lake | 10 | 0.948 | 0.006 | 0.064 |
| Center Lake | 10 | 0.956 | 0.012 | 0.120 |
| Calf Camp Marsh | 10 | 0.954 | 0.015 | 0.133 |
| *Tryon | 10 | 0.608 | 0.031 | 0.731 |
| Tom's Lake | 10 | 0.545 | 0.063 | 0.589 |
| "21" Lake | 10 | 0.567 | 0.050 | 0.487 |
| Center Lake | 10 | 0.558 | 0.062 | 0.646 |
| Calf Camp Marsh | 10 | 0.761 | 0.051 | 0.532 |
| Els | 30 | 0.407 | 0.022 | 0.517 |
| Tom's Lake | 10 | 0.317 | 0.024 | 0.281 |
| Center Lake | 10 | 0.503 | 0.026 | 0.251 |
| Calf Camp Marsh | 10 | 0.402 | 0.039 | 0.434 |
| Ipage | 10 | 0.376 | 0.028 | 0.271 |
| "21" Lake | 10 | 0.376 | 0.028 | 0.271 |

(Continued)

Table 7. (Concluded).

| Soil series/[a] Wetland | n | Mean | Standard error of means | Range |
|---|---|---|---|---|
| CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | | | |
| *Marlake | 109 | 0.874 | 0.009 | 0.410 |
| Martin Lake | 10 | 0.962 | 0.012 | 0.123 |
| Section 30E Marsh | 10 | 0.911 | 0.017 | 0.180 |
| Perrin Lake | 10 | 0.795 | 0.047 | 0.410 |
| Goose Lake | 19 | 0.887 | 0.015 | 0.241 |
| Island Lake | 20 | 0.825 | 0.026 | 0.374 |
| Roundup Lake | 20 | 0.918 | 0.013 | 0.262 |
| Gimlet Lake | 20 | 0.845 | 0.011 | 0.216 |
| *Loup | 40 | 0.666 | 0.019 | 0.431 |
| Goose Lake | 20 | 0.652 | 0.026 | 0.420 |
| Gimlet Lake | 20 | 0.680 | 0.027 | 0.365 |
| *Hoffland | 40 | 0.644 | 0.024 | 0.671 |
| Section 30E Marsh | 20 | 0.638 | 0.035 | 0.504 |
| Perrin Lake | 10 | 0.645 | 0.061 | 0.654 |
| Goose Lake | 10 | 0.656 | 0.026 | 0.281 |
| *Tryon | 40 | 0.402 | 0.028 | 0.670 |
| Island Lake | 20 | 0.277 | 0.018 | 0.240 |
| Roundup Lake | 20 | 0.526 | 0.036 | 0.533 |
| Els | 70 | 0.251 | 0.020 | 0.820 |
| Martin Lake | 10 | 0.308 | 0.047 | 0.370 |
| Section 30E Marsh | 10 | 0.198 | 0.023 | 0.222 |
| Perrin Lake | 10 | 0.542 | 0.058 | 0.533 |
| Island Lake | 20 | 0.173 | 0.023 | 0.472 |
| Gimlet Lake | 20 | 0.182 | 0.012 | 0.227 |
| Valentine | 40 | 0.145 | 0.011 | 0.272 |
| Goose Lake | 20 | 0.168 | 0.009 | 0.188 |
| Roundup Lake | 20 | 0.123 | 0.018 | 0.272 |

[a]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).

Table 8. Duncan's multiple range tests for weighted averages calculated for soil series.

| Grouping[a] | Soil series[b] | Mean | n[c] |
|---|---|---|---|
| | RAINWATER BASIN | | |
| A | Butler | 3.221 | 38 |
| B | *Scott | 2.855 | 39 |
| C | *Fillmore | 2.445 | 40 |
| D | *Massie | 1.413 | 40 |
| | ROCK COUNTY | | |
| A | *Tryon | 2.474 | 40 |
| A | *Loup | 2.278 | 40 |
| B | *Marlake | 1.280 | 40 |
| | VALENTINE NATIONAL WILDLIFE REFUGE | | |
| A | Ipage | 3.339 | 10 |
| A | Els | 3.235 | 30 |
| B | *Tryon | 2.532 | 40 |
| C | *Marlake | 1.257 | 40 |
| | CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | |
| A | Valentine | 4.265 | 40 |
| B | Els | 3.827 | 70 |
| C | *Tryon | 3.308 | 40 |
| D | *Loup | 2.471 | 40 |
| D | *Hoffland | 2.399 | 40 |
| E | *Marlake | 1.584 | 109 |

(Continued)

Table 8. (Concluded).

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[a]Mean values for soil series with the same letter grouping are not statistically different at 0.05 level.
[b]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).
[c]Ideally, 40 observations were made within each hydric and nonhydric soil series. However, some deviations existed in our data set. In the Rainwater Basin, two observations are missing from the Butler series due to an error in data collection; one quadrat in the Scott series consisted of all unknown species, and thus was not incorporated into our analyses. No nonhydric soils were sampled in Rock County due to our oversight. Two nonhydric series were combined at Valentine National Wildlife Refuge (30 observations in the Els and 10 in the Ipage series) because of soil identification problems (see Methods section). Additional observations in the Marlake and Els series at Crescent Lake National Wildlife Refuge were made in conjunction with the Hoffland series to compare alkaline wetlands (containing Hoffland soils) and freshwater wetlands at a later date.

Table 9. Duncan's multiple range tests for presence/absence averages calculated for soil series.

| Grouping[a] | Soil series[b] | Mean | n |
|---|---|---|---|
| | RAINWATER BASIN | | |
| A | Butler | 3.229 | 38 |
| B | *Scott | 2.836 | 39 |
| C | *Fillmore | 2.466 | 40 |
| D | *Massie | 1.427 | 40 |
| | ROCK COUNTY | | |
| A | *Tryon | 2.491 | 40 |
| A | *Loup | 2.354 | 40 |
| B | *Marlake | 1.309 | 40 |
| | VALENTINE NATIONAL WILDLIFE REFUGE | | |
| A | Ipage | 3.290 | 10 |
| A | Els | 3.158 | 30 |
| B | *Tryon | 2.516 | 40 |
| C | *Marlake | 1.264 | 40 |
| | CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | |
| A | Valentine | 4.207 | 40 |
| B | Els | 3.808 | 70 |
| C | *Tryon | 3.306 | 40 |
| D | *Loup | 2.490 | 40 |
| D | *Hoffland | 2.411 | 40 |
| E | *Marlake | 1.662 | 109 |

(Continued)

Table 9. (Concluded)

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[a]Mean values for soil series with the same letter grouping are not statistically different.
[b]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).

Table 10. Duncan's multiple range tests for Michener averages calculated for soil series.

| Grouping[a] | Soil series[b] | Mean | n |
|---|---|---|---|
| | RAINWATER BASIN | | |
| A | *Massie | 0.907 | 40 |
| B | *Fillmore | 0.639 | 40 |
| C | *Scott | 0.522 | 39 |
| D | Butler | 0.415 | 38 |
| | ROCK COUNTY | | |
| A | *Marlake | 0.933 | 40 |
| B | *Loup | 0.677 | 40 |
| B | *Tryon | 0.624 | 40 |
| | VALENTINE NATIONAL WILDLIFE REFUGE | | |
| A | *Marlake | 0.951 | 40 |
| B | *Tryon | 0.608 | 40 |
| C | Els | 0.407 | 30 |
| C | Ipage | 0.376 | 10 |
| | CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | |
| A | *Marlake | 0.874 | 109 |
| B | *Loup | 0.666 | 40 |
| B | *Hoffland | 0.644 | 40 |
| C | *Tryon | 0.402 | 40 |
| D | Els | 0.251 | 70 |
| E | Valentine | 0.145 | 40 |

(Continued)

Table 10. (Concluded).

[a]Mean values for soil series with the same letter grouping are not statistically different.
[b]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).

Table 11. Duncan's multiple range tests for comparisons among weighted averages and presence/absence averages calculated for soil series.

| Soil series[a] | Grouping[b] | Weighted average | Presence/absence average | n |
|---|---|---|---|---|
| | | RAINWATER BASIN | | |
| BUTLER | A | 3.221 | 3.229 | 38 |
| *SCOTT | B | 2.855 | 2.836 | 39 |
| *FILLMORE | C | 2.445 | 2.466 | 40 |
| *MASSIE | D | 1.413 | 1.427 | 40 |
| | | ROCK COUNTY | | |
| *TRYON | A | 2.474 | 2.491 | 40 |
| *LOUP | A | 2.278 | 2.354 | 40 |
| *MARLAKE | B | 1.280 | 1.309 | 40 |
| | | VALENTINE NATIONAL WILDLIFE REFUGE | | |
| IPAGE | A | 3.339 | 3.290 | 10 |
| ELS | A | 3.235 | 3.158 | 30 |
| *TRYON | B | 2.532 | 2.516 | 40 |
| *MARLAKE | C | 1.257 | 1.264 | 40 |
| | | CRESCENT LAKE NATIONAL WILDLIFE REFUGE | | |
| VALENTINE | A | 4.265 | 4.207 | 40 |
| ELS | B | 3.827 | 3.808 | 70 |
| *TRYON | C | 3.308 | 3.306 | 40 |
| *HOFFLAND | D | 2.471 | 2.490 | 40 |
| *LOUP | D | 2.399 | 2.411 | 40 |
| *MARLAKE | E | 1.584 | 1.662 | 109 |

(Continued)

Table 11. (Concluded).

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[a]Asterisks (*) indicate the soil series is included in the Hydric Soils List (Soil Conservation Service 1985b).

[b] Mean values for soil series with the same letter grouping are not statistically significant.

Designations by Michener average corresponded well with those for weighted and presence/absence averages; indices greater than 0.50 indicated that a soil series contained a prevalence of hydrophytic vegetation (Table 10). As with weighted and presence/absence averages, Michener calculations did not indicated that the Tryon series at Crescent Lake National Wildlife Refuge supported primarily hydrophytic vegetation (Table 11).

## DISCUSSION

Little information is available regarding Nebraska wetlands, and no known publications focus on vegetation-soil correlations in the State. An early survey of Sandhill vegetation by Rydberg (1895) categorized wetland vegetation into wet-valley and aquatic flora categories. Remote sensing of wetland vegetation communities was used to delineate selected Sandhill wetlands in Cherry County (Gilbert 1980; Gilbert et al. 1980). Currier (1981) identified 22 vegetation communities from the Platte River floodplain, Nebraska. The U.S. Army Corps of Engineers (1983) used vegetational zones (xeric, mesic, or hydric) to delineate wetlands in Garfield and Wheeler counties in the Sandhills. Rundquist (1983) used remote sensing to quantify historic changes in Sandhill wetland acreage by the Shaw and Fredine (1956) classification. The Rainwater Basin is the site of an ongoing cooperative research project conducted by the U.S. Army Corps of Engineers, Environmental Protection Agency, Nebraska Game and Parks Commission, and U.S. Fish and Wildlife Service; wetland types within the basin are being evaluated using vegetation and soil parameters.

Advantages and disadvantages existed for all averaging methods used in our study to correlate vegetation and soil parameters. Weighted and Michener averages used occular estimates of percent cover, which could have increased experimental error; however, consistency was achieved by having these estimates made by the same researcher. Michener averages, using weighted ecological indices, adequately indicated a prevalence of hydrophytic vegetation on SCS hydric soils, and would be a suitable method for delineating wetland systems using vegetation and soil parameters. Proper identification of species and correct classification by ecological indices are critical for accurate weighted and presence/absence average calculations (Wentworth and Johnson 1986).

Comparisons between weighted and presence/absence averages indicated no statistical differences among calculated values for soil series. Excellent agreement between these two methods was noted in Wentworth and Johnson's (1986) analyses of Currier's (1981) vegetation community data. Percent cover as a measure of dominance for a species in a given soil series was incorporated into weighted averages but not in presence/absence average calculations. Species dominance apparently did not influence whether or not the averages correlated with hydric soils. Rather, ecological indices, which reflected frequency of occurrence in wetlands, provided sufficient information to determine a prevalence of hydrophytic vegetation for a given soil.

Although exclusive use of presence/absence averages could prove adequate in assessing wetlands, these calculations may represent too simplistic an

approach for complex wetlands. It has not been ascertained whether these calculations would produce similar results for separation of soils within other vegetation strata, because trees and shrubs were not present in testable quantities in the Rainwater Basin and Sandhills of Nebraska. Similar methods have been used to distinguish among vegetation communities, including ground cover, shrub, and tree strata (Wentworth and Johnson 1986). Therefore, presence/absence averaging probably would distinguish between hydric and nonhydric soils within shrub and tree strata.

Hydrological parameters were not incorporated into our analyses; however, moisture variances among study sites in soil series may have influenced our results. Weighted, presence/absence, and Michener average calculations for the Tryon series, a known hydric soil, indicated the series to be hydric in Rock County and Valentine National Wildlife Refuge, whereas the series was designated nonhydric at Crescent Lake National Wildlife Refuge. Two factors might account for this discrepency. First, annual precipitation at Crescent Lake National Wildlife Refuge reportedly was below normal, which may have influenced species composition within study plots. Second, values calculated for Tryon series fell into the hydric category at Roundup Lake but not at Island Lake; the latter showed evidence of recent grazing in the Tryon series. Grazing at Island Lake may have altered plant species composition, thus affecting our calculations. Modified wetlands generally were not encorporated into our study, but because the Tryon series was abundant only in two wetlands in the refuge, the impacted area was included in our study.

Although the Butler series in the Rainwater Basin was not included in the Hydric Soils List, it has been considered a hydric soil by some biologists of the U.S. Fish and Wildlife Service. The Butler series, located above the Scott series in the landscape, was somewhat drier than the Scott; however, both series supported similar plant species. Scott (included in the list) and Butler soil plots most often were dominated by hydrophytes, such as _Panicum virgatum_ (facultative) and _Polygonum amphibium_ (obligate), in addition to more upland species; for example, _Poa nemoralis_, _Ambrosia artemisiifolia_, and _Bromus inermis_. Isolated outcroppings of Butler soils reportedly are more prone to agricultural modification, which discourages development of hydrophytic communities. Yet, when the Butler series is found in conjunction with other hydric series, such as Massie, Fillmore, and Scott, it supports a prevalence of hydrophytic vegetation (T. Taylor, pers. comm.).

In conclusion, our study was performed within known soil series, and areas where the identity of a soil series was not clearly defined were avoided. The application of these methodologies to delineate wetlands based on soil and vegetation should consider the constraints and limitations discussed herein.

## CONCLUSIONS

Generally, prevalence indices of ground cover vegetation (i. e., weighted, presence/absence, and Michener averages) correlated with hydric/nonhydric soil series designations of the Soil Conservation Service. Degree of correlation among calculated values and known hydric soils from the Hydric Soils List determined the adequacy of the methods. Use of weighted ecological indices in Michener averages corresponded well to prevalence of hydrophytic vegetation in hydric soil series, and would be adequate for wetland delineation. However, weighted averages or presence/absence averages also gave good results, and would be suitable for delineating wetlands based on vegetation-soil relationships.

Weighted and presence/absence averages within soil series were not statistically different using Duncan's multiple range tests. Presence/absence average calculations do not require information regarding species dominance, and thus may be preferred. However, correct identification of all species within the area of question then becomes critical to generate accurate values for the presence/absence method, because all species are weighted equally within the soil series. Furthermore, analyses were not performed for shrub and tree strata because of insufficient abundance in the Rainwater Basin and Sandhills regions. It is inconclusive whether weighted and presence/absence averages would be comparable for these strata.

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# APPENDIX A

## DESCRIPTIONS OF SOIL SERIES

BUTLER: occurs above Scott and Fillmore series in the landscape; deep, nearly level, with a slope of 0-1%; somewhat poorly drained soils formed in loess or mixed loess and alluvium on uplands and high stream terraces; surface layer is dark grey silt loam 25 cm thick; subsurface layer is grey silt loam 5 cm thick, subsoil layer is very dark grey, very firm silty clay in upper 51 cm and dark grey, firm silty clay in lower 15 cm; substratum is grey silt loam; organic matter content is moderate and natural fertility is medium; mean annual precipitation range is 56-76 cm and mean annual temperature range is 9-13 °C; permeability is slow; most areas of this soil are farmed through irrigation or dryfarming; other areas exist as native grass, usually adjacent to wetlands; southcentral Nebraska and northcentral Kansas distribution.

ELS: occurs above Loup and Tryon and below Ipage series in the landscape; deep, poorly drained soil, with 0-3% slope; formed in aeolian and alluvial sands on depressed areas and valleys of the Sandhills and on foot slopes and stream terraces draining the Sandhills; surface layer is greyish brown fine sand 18 cm thick; subsoils layer is light brownish grey fine sand 18 cm thick; substratum is light grey mottled fine sand; mean annual precipitation range is 36-69 cm and mean annual temperature range is 8-11 °C; runoff is slow and permeability is rapid; most of the acreage is used for hayland or range; native vegetation is grassland; some acreage used for alfalfa, corn, grain sorghum, wheat, and introduced grasses; Nebraska Sandhills, Kansas, South Dakota, and Colorado distribution.

FILLMORE: occurs above Massie and below Butler series in the landscape; deep nearly level, with a slope of 0-1%; poorly drained claypan soil formed in loess in shallow depressions or basins of uplands and stream terraces; surface layer is grey silt loam 23 cm thick; subsurface layer is light grey silt loam 10 cm thick; subsoil layer is dark greyish brown, very firm clay in upper 19 in and greyish brown silty clay loam in lower 30 cm; substratum is pale brown silt loam; organic matter content is moderate and natural fertility is medium; mean annual precipitation range is 51-89 cm and mean annual temperature range is 10-13 °C; runoff is very slow or ponded and permeability of water and air is very slow in the claypan subsoil; about half the areas of this soil are farmed, and are primarily dryfarmed; the rest is in native grasses used for grazing, haying, and as wildlife habitat; southcentral and eastern Nebraska, and possibly northern Kansas distribution.

HOFFLAND: occurs above Marlake and below Els series in the landscape; deep, poorly drained soils, with 0-2% slope; formed in alluvial sediments in Sandhill valleys; high calcium carbonate content; surface soil is grey and light brownish grey fine sandy loam 28 cm thick; substratum is 76 cm light brownish grey fine sand over 20 cm dark greyish brown fine sandy loam over light grey fine sand; mean annual precipitation range is 38-46 cm and mean annual temperature range is 7-9 °C; runoff is slow or ponded, and permeability is rapid; nearly all acreage is in native grass and used for hayland and range; in the western Nebraska Sandhills distribution.

IPAGE: occurs above Els, Loup, and Tryon and below Valentine series in the landscape; deep, moderately well drained, with 0-6% slope; formed in aeolian and alluvial sands on upland valleys and along stream terraces; surface layer is dark greyish brown sand 13 cm thick; subsoil layer is greyish brown sand 15 cm thick; substratum is pale brown sand and very pale brown and white sand over light grey coarse sand 109 cm thick; mean annual precipitation range is 41-61 cm and mean annual temperature range is 8-11 °C; runoff is slow and permeability is rapid; principally used as hayland and range, but a small acreage is cultivated to corn and alfalfa; most of the acreage in corn is irrigated; native vegetation is grassland; Nebraska Sandhills and South Dakota distribution.

LOUP: occurs above Marlake and below Els series in the landscape; deep, nearly level, with a 0-2% slope; poorly drained soil formed in loamy and sandy alluvium bottomlands and around marshes and lakes; presence of mollic epipedon; surface layer is calcareous, very dark grey, and dark grey fine sandy loam 25 cm thick; subsurface layer is grey fine sand 10 cm thick; substratum is 109 cm of light grey and greyish brown fine sand over dark grey fine sandy loam; organic matter content is high; mean annual precipitation range is 38-66 cm and mean annual temperature range is 7-12 °C; permeability is rapid; depth to the water table ranges from 15-30 cm; soil is in native grass and is used for rangeland or hayland, but usually is too wet for farming; Nebraska Sandhills, South Dakota, and Colorado distribution.

MARLAKE: occurs below Hoffland, Loup, Tryon, Els, and Valentine series in the landscape; deep, nearly level, with 0-1% slope; poorly drained soil formed in colluvial and alluvial sands; located in depressions or basins on valley floors and in low areas bordering lakes and streams; surface layer is dark grey loamy fine sand 18 cm thick; subsoil is greyish brown loamy sand with thin strata of sandy loam and sand 23 cm thick; substratum is light grey mottled fine sand; organic matter content is high; mean annual precipitation range is 43-58 cm and mean annual temperature range is 8-11 °C; usually inundated during the growing season; permeability is high; soil used mostly as wildlife habitat; some areas are mowed in dry years for mulching materials; north-central, central, and western Nebraska distribution.

MASSIE: occurs below Scott and Fillmore series in the landscape; deep, nearly level, with 0-1% slope; very poorly drained claypan soil formed in loess modified by water in the lowest, wettest depressions or basins of uplands; typically there is a layer of partially decayed leaves and stems on the surface; surface layer is very dark grey, grey, or light grey silty clay loam 23 cm thick; subsoil layer is dark grey silty clay and silty clay loam in the upper 41 cm and grey and dark greyish brown clay and silty clay in the lower 127 cm; substratum is greyish brown silty clay loam; organic matter content is high and natural fertility is medium; mean annual precipitation range is 51-66 cm and mean annual temperature range is 10-12 °C; usually inundated to 15 cm during the growing season; permeability is very low in the claypan subsoil; the soil is in wetland vegetation and is used mainly by wildlife; it is unsuited to dryland farming or irrigation,

rangeland, and windbreaks; south-central and southeastern Nebraska distribution.

SCOTT: occurs above Massie and below Butler series in the landscape; deep, nearly level, with a 0-1% slope; very poorly drained claypan soil formed in loess or loess modified by water in the lower parts of depressions or basins of uplands; surface layer is very dark grey silt loam 13 cm thick; subsurface layer is grey silt loam 8 cm thick; subsoil layer is very dark grey mottled very firm silty clay and clay in upper 66 cm and dark greyish brown silty clay loam in lower 30 cm; substratum is brown silt loam; organic matter content is moderate, and natural fertility is medium; mean annual precipitation range is 41-71 cm and mean annual temperature range is 10-13 $^{o}C$; soils are ponded for long durations and permeability is very slow in the claypan subsoil; nearly all areas of this soil are in wetland vegetation and native grasses; areas are used as wildlife habitat and for grazing and haying; other areas are farmed, but are unsuitable for irrigation; western and central Nebraska and adjoining areas of Kansas and northeast Colorado distribution.

TRYON: occurs above Marlake and below Els series in the landscape; deep, nearly level, with a 0-2% slope; formed in aeolian and alluvial sediments in Sandhill valley floors and on bottomlands of some major streams which drain the Sandhills; lacks mollic epipedon; surface layer is very dark brown loamy fine sand 13 cm thick; subsurface layer is light brownish grey loamy sand to grey fine sand 14-23 cm thick; substratum is 104 cm of light brownish grey fine sand over 18 cm of black fine sandy loam over dark grey fine sand; organic matter content is high; mean annual precipitation range is 36-61 cm and mean annual temperature range is 8-11 $^{o}C$; permeability is rapid; soil is suited to grazing or haying, but is too wet for cultivation; Nebraska Sandhills and central Great Plains distribution.

VALENTINE: occurs above Els, Loup, and Tryon series in the landscape; deep, excessively drained, with 0-6% slope; formed in aeolian sands; surface soil is dark greyish brown loamy fine sand 38 cm thick; subsoil is 64 cm of pale brown fine sand over clay and shaley clay; mean annual precipitation range is 41-64 cm and mean annual temperature range is 8-15 $^{o}C$; runoff is slow due to rapid infiltration and permeability is rapid; capability to hold water is low; soils are dominated by native grass and are used for grazing and haying; some areas have been cultivated, but unless irrigated have returned to grass; north-central Nebraska, South Dakota, and Kansas distribution.

APPENDIX B

ALPHABETICAL LISTING OF SCIENTIFIC NAMES, CODES, AND NATIONAL WETLAND INVENTORY ECOLOGICAL INDICES OF PLANT SPECIES IDENTIFIED IN THE SANDHILLS AND RAINWATER BASIN WETLANDS OF NEBRASKA

LEGEND

SCIENTIFIC NAME: Scientific name for species.

CODE: Four to six character code assigned to species in the National Wetland Plant Inventory List (Reed 1986a).

E: Ecological index for species: ob = obligate, fw = facultative wetland, wd = facultative wetland favored by drawdown, fa = facultative, fd = facultative favored by drawdown, fu = facultative upland, ud = facultative upland favored by drawdown, up = upland, nc = not classified in the National Wetland Plant Inventory List; (see Table 3).

| SCIENTIFIC NAME | CODE | E |
|---|---|---|
| Acer negundo | acne2 | fa |
| Achillea millefolium | acmi2 | fu |
| Adiantum pedatrum | adpe | fa |
| Agropyron cristatum | agcr | fa |
| Agropyron repens | agre | fw |
| Agropyron smithii | agsm | fu |
| Agropyron trachycaulum | agtr | fu |
| Agrostis exarata | agex | fw |
| Agrostis spp. | agros | fa |
| Agrostis stolonifera | agst2 | fa |
| Algae | algae | ob |
| Alisma plantago-aquatica | alpl | ob |
| Alopecurus geniculatus | alge2 | ob |
| Amaranthus retroflexus | amre | fu |
| Ambrosia artemisiifolia | amar2 | ud |
| Ambrosia psilostachya | amps | fa |
| Ambrosia trifida | amtr | fw |
| Amorpha cannescens | amca6 | up |
| Andropogon scoparius [a] | ansc2 | fu |
| Antennaria neglecta | anne | fu |
| Apocynum cannabinum | apca | fa |
| Apocynum sibericum | apsi | fa |
| Artemisia campestris | arcal2 | fu |
| Artemisia cana | arcal3 | fu |
| Asclepias incarnata | asin | ob |
| Asclepias speciosa | assp | fu |
| Asclepias spp. | ascle | fu |
| Aster ericoides | aser3 | fu |
| Aster spp. | aster | fa |
| Bidens frondosa | bifr | fw |
| Bromus inermis | brin2 | fu |
| Bromus japonicus | brja | fu |
| Bromus tectorum | brte | fu |
| Calamagrostis inexpansa | cain | fw |
| Carex alopecoidea | caal8 | fw |
| Carex arctata | caar3 | fw |
| Carex atherodes | caat2 | ob |
| Carex aurea | caau | fw |
| Carex haydenii | caha7 | ob |
| Carex interior | cainl1 | ob |
| Carex laevivaginata | calal4 | ob |
| Carex lanuginosa | cala30 | ob |
| Carex lasiocarpa | calal6 | ob |
| Carex nebraskensis | cane2 | ob |
| Carex scoparia | cascl1 | fw |
| Carex spp. | carex | fw |
| Carex straminea | cast6 | ob |
| Carex stricta | cast8 | ob |
| Carex suberecta | casu5 | ob |
| Carex torreyi | cato3 | fw |

| | | |
|---|---|---|
| Carex vulpinoidea | cavu2 | ob |
| Cerastium vulgatum | cevu | fu |
| Chara vulgaris | chvu | ob |
| Chenopodium album | chal7 | fa |
| Chenopodium hybridum | chhy | fu |
| Chenopodium rubrum | chru | ob |
| Chenopodium spp. | cheno | fu |
| Cicuta bulbifera | cibu | ob |
| Cicuta maculata | cima2 | ob |
| Cirsium muticum | cimu | fw |
| Cirsium spp. | cirsi | fu |
| Cirsium undulatum | ciun | fu |
| Cirsium vulgare | civu | fu |
| Commelina spp. | comme | fa |
| Compositae | compos | nc |
| Conyza canadensis | coca5 | fu |
| Coreopsis tinctoria | coti3 | fa |
| Cornus drummondii | codr | fa |
| Cruciferaceae | crucif | up |
| Cyperaceae | cypera | nc |
| Cyperus spp. | cyper | fa |
| Dalea enneandra | daen | fw |
| Decodon verticillata | deve | ob |
| Dictylis spicata | disp | fw |
| Drava auricularia | drau | fa |
| Drepanocladus | drepa | ob |
| Eleocharis palustris | elpa3 | ob |
| Eleocharis spp. | eleoc | fw |
| Elymus canadensis | elca4 | fu |
| Elymus spp. | elymu | fu |
| Equisetum fluviatile | eqfl | ob |
| Equisetum laevigatum | eqla | fw |
| Equisetum palustre | eqpa | fw |
| Eragrostis spp. | eragr | fu |
| Erigeron flagellaris | erfl | fa |
| Erigeron philidelphicus | erph | fa |
| Erigeron strigosus | erst3 | fa |
| Eulalia viminea | euvi | fa |
| Fabaceae | fabace | nc |
| Galium aparine | gaap2 | fu |
| Galium obtusum | gaob | fw |
| Galium spp. | galiu | fu |
| Galium trifidum | gatr2 | ob |
| Glycyrrhiza lepidota | glle3 | fu |
| Gramineae | gramin | nc |
| Helianthus annuus | hean3 | fa |
| Helianthus maximiliani | hema2 | up |
| Helianthus rigida | heri2 | up |
| Helianthus spp. | helia | up |
| Hordeum jubatum | hoju | fw |
| Hypericum canadense | hyca7 | fw |
| Hypoxis hirsuta | hyhi2 | fw |
| Impatiens capensis | imca | fw |
| Ipomoea leptophylla | iple | fu |

| | | |
|---|---|---|
| Ipomoea spp. | ipomo | fu |
| Juncus balticus | juba | ob |
| Juncus inflexus | juin | fw |
| Juncus spp. | juncu | fw |
| Juncus tenuis | jute | fa |
| Juniperus virigiana | juvi | fu |
| Kochia scoparia | kosc | ud |
| Koelaria pyrimidata | kopy | up |
| Lactuca canadensis | laca | ud |
| Lactuca serriola | lase | fd |
| Lactuca spp. | lactu | fa |
| Lathyrus polymorphus | lapo2 | fa |
| Lemna minor | lemi3 | ob |
| Lemna trifida | letr | ob |
| Lepidium latifolium | lela2 | fw |
| Lotus pershianus | lopu3 | fu |
| Lygodesmia juncea | lyju | up |
| Lysimachia ciliata | lyci | fw |
| Lysimachia hybrida | lyhy | ob |
| Melilotus alba | meal2 | ud |
| Melilotus spp. | melil | fu |
| Mentha arvensis | mear4 | fw |
| Mentzella decapetalla | mede2 | up |
| Oenothera biennis | oebi | fu |
| Oenothera nuttallii | oenu | fu |
| Oenothera spp. | oenot | fu |
| Ophioglossum vulgatum | opvu | fw |
| Opuntia imbricata | opim | up |
| Oxalis corniculata | oxco | fu |
| Panicum dichotomiflorum | padi | fa |
| Panicum dichotomum | padi2 | fu |
| Panicum scribnerinum | pasc5 | fu |
| Panicum virgatum | pavi2 | fa |
| Parietaria pensylvanica | pape5 | fa |
| Phalaris arundinacea | phar3 | fw |
| Phleum pratense | phpr3 | fu |
| Phragmites communis | phco | fw |
| Physalis angulata | phan5 | fu |
| Physalis heterophylla | phhe5 | fu |
| Plantago eriopoda | pler | fa |
| Plantago patagonica | plpa2 | up |
| Poa alsodes | poal3 | fw |
| Poa compressa | poco | fu |
| Poa nemoralis | pone | fa |
| Poa pratensis | popr | fu |
| Poa spp. | poa | fu |
| Polygonum amphibium | poam8 | ob |
| Polygonum hydropiper | pohy | ob |
| Polygonum hydropiperoides | pohy2 | ob |
| Polygonum lapathifolium | pola4 | ob |
| Polygonum pensylvanicum | pope2 | fw |
| Polygonum spp. | polyg | nc |
| Populus deltoides | pode3 | fd |
| Potentilla paradoxa | popal5 | fa |

| | | |
|---|---|---|
| Potentilla spp. | poten | fu |
| Psoralea argophylla | psar2 | fu |
| Ranunculaceae | ranunc | fu |
| Ratibida columnifera | raco3 | up |
| Riccia fluitans | rifl | ob |
| Rorippa sinuata | rosi | fw |
| Rosa spp. | rosa | fu |
| Rudbeckia hirta | ruhi2 | fu |
| Rumex acetosella | ruac3 | fa |
| Rumex britannica | rubr | ob |
| Rumex crispus | rucr | wd |
| Rumex spp. | rumex | fa |
| Rumex verticillata | ruve3 | fw |
| Sagittaria spp. | sagit | ob |
| Salix exigua | saex | ob |
| Salix nigra | sani | ob |
| Salsola kali | saka | ud |
| Schizachyrium scoparium [a] | scsc | ud |
| Scirpus acutus | scac | ob |
| Scirpus americanus | scam2 | ob |
| Scirpus fluviatilis | scfl | ob |
| Scirpus robustus | scro | ob |
| Scirpus spp. | scirp | fw |
| Scirpus torreyii | scto | ob |
| Scutellaria galericulata | scga | ob |
| Silene antirrhina | sian2 | fu |
| Sisyrinchium angustifolium | sian3 | fa |
| Smilacina stellata | smst | fa |
| Solanum nigrum | soni | fu |
| Solanum spp. | solan | fu |
| Solidago canadensis | soca6 | fu |
| Solidago gigantea | sogi | fw |
| Solidago rigida | sori | fu |
| Solidago spp. | solid | fu |
| Sorghastrum nutans | sonu2 | fu |
| Sparganium chlorocarpum | spch | ob |
| Sparganium eurycarpum | speu | ob |
| Spartina pectinata | sppe | fw |
| Spirodela polyrhiza | sppo | ob |
| Stipa comata | stco4 | up |
| Stipa spartea | stsp2 | up |
| Stipa viridula | stvi4 | up |
| Strophostyles leiosperma | stle6 | fu |
| Symphoricarpos occidentalis | syoc | fu |
| Talinum teretifolium | tate | fu |
| Taraxacum officinale | taof | fu |
| Teucrium canadense | teca3 | fw |
| Toxicodendron radicans | tora2 | fu |
| Tragopogon dubius | trdu | up |
| Trifolium pratense | trpr2 | fu |
| Trifolium procumbens | trpr3 | fu |
| Triglochin maritimum | trma4 | ob |
| Triodanis perfoliata | trpe4 | fa |
| Typha angustifolia | tyan | ob |

| | | |
|---|---|---|
| Typha latifolia | tyla | ob |
| Unknown Forb | uf | nc |
| Urtica dioecia | urdi | fw |
| Utricularia macrorhiza | utma | ob |
| Vernonia baldwinii | veba | fu |
| Vernonia fasciculata | vefa2 | fa |
| Vernonia spp. | verno | fa |
| Veronica americana | veam2 | ob |
| Veronica spp. | veron | fa |
| Viola spp. | viola | fu |
| Xanthium strumarium | xast | fd |
| Yucca spp. | yucca | fu |

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[a] Andropogon scoparius and Schizachyrium scoparium are the same species (the latter is correct).

# APPENDIX C

## FREQUENCIES OF OCCURRENCE OF SPECIES FOUND ON SOIL SERIES WITHIN EACH STUDY AREA

Appendix C-1. Frequency of occurrence of species found on 40 replications of Massie soil, Rainwater Basin.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| elpa3 | 358 | 18.8 | 358 | 18.8 |
| poam8 | 327 | 17.2 | 685 | 36.0 |
| algae | 300 | 15.8 | 985 | 51.7 |
| pavi2 | 265 | 13.9 | 1250 | 65.7 |
| phar3 | 153 | 8.0 | 1403 | 73.7 |
| spch | 82 | 4.3 | 1485 | 78.0 |
| arcal3 | 64 | 3.4 | 1549 | 81.4 |
| cala30 | 55 | 2.9 | 1604 | 84.2 |
| tyla | 52 | 2.7 | 1656 | 87.0 |
| teca3 | 46 | 2.4 | 1702 | 89.4 |
| pola4 | 44 | 2.3 | 1746 | 91.7 |
| casu5 | 43 | 2.3 | 1789 | 94.0 |
| brin2 | 31 | 1.6 | 1820 | 95.6 |
| sagit | 16 | 0.8 | 1836 | 96.4 |
| juba | 15 | 0.8 | 1851 | 97.2 |
| uf | 14 | 0.7 | 1865 | 98.0 |
| cibu | 13 | 0.7 | 1878 | 98.6 |
| hoju | 7 | 0.4 | 1885 | 99.0 |
| vefa2 | 7 | 0.4 | 1892 | 99.4 |
| apsi | 3 | 0.2 | 1895 | 99.5 |
| rubr | 3 | 0.2 | 1898 | 99.7 |
| amar2 | 2 | 0.1 | 1900 | 99.8 |
| oxco | 2 | 0.1 | 1902 | 99.9 |
| drepa | 1 | 0.1 | 1903 | 99.9 |
| rucr | 1 | 0.1 | 1904 | 100.0 |

Appendix C-2. Frequency of occurrence of species found on 40 replications of Fillmore soil, Rainwater Basin.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| amar2 | 354 | 15.7 | 354 | 15.7 |
| phar3 | 342 | 15.1 | 696 | 30.8 |
| agst2 | 276 | 12.2 | 972 | 43.0 |
| elpa3 | 204 | 9.0 | 1176 | 52.1 |
| pone | 146 | 6.5 | 1322 | 58.5 |
| poam8 | 139 | 6.2 | 1461 | 64.7 |
| alge2 | 102 | 4.5 | 1563 | 69.2 |
| cala30 | 90 | 4.0 | 1653 | 73.2 |
| meal2 | 90 | 4.0 | 1743 | 77.2 |
| coca5 | 73 | 3.2 | 1816 | 80.4 |
| hoju | 59 | 2.6 | 1875 | 83.0 |
| rucr | 50 | 2.2 | 1925 | 85.3 |
| mear4 | 46 | 2.0 | 1971 | 87.3 |
| cane2 | 29 | 1.3 | 2000 | 88.6 |
| verno | 25 | 1.1 | 2025 | 89.7 |
| pohy | 24 | 1.1 | 2049 | 90.7 |
| compos | 23 | 1.0 | 2072 | 91.8 |
| arcal3 | 21 | 0.9 | 2093 | 92.7 |
| cibu | 21 | 0.9 | 2114 | 93.6 |
| lase | 21 | 0.9 | 2135 | 94.6 |
| gramin | 19 | 0.8 | 2154 | 95.4 |
| brin2 | 14 | 0.6 | 2168 | 96.0 |
| amtr | 10 | 0.4 | 2178 | 96.5 |
| uf | 9 | 0.4 | 2187 | 96.9 |
| acmi2 | 7 | 0.3 | 2194 | 97.2 |
| lela2 | 7 | 0.3 | 2201 | 97.5 |
| lopu3 | 6 | 0.3 | 2207 | 97.7 |
| oxco | 6 | 0.3 | 2213 | 98.0 |
| teca3 | 6 | 0.3 | 2219 | 98.3 |
| ciun | 5 | 0.2 | 2224 | 98.5 |
| pola4 | 5 | 0.2 | 2229 | 98.7 |
| veam2 | 5 | 0.2 | 2234 | 98.9 |
| apsi | 4 | 0.2 | 2238 | 99.1 |
| cimu | 4 | 0.2 | 2242 | 99.3 |
| gaap2 | 4 | 0.2 | 2246 | 99.5 |
| asin | 3 | 0.1 | 2249 | 99.6 |
| cirsi | 2 | 0.1 | 2251 | 99.7 |
| poten | 2 | 0.1 | 2253 | 99.8 |
| solid | 2 | 0.1 | 2255 | 99.9 |
| calal6 | 1 | 0.0 | 2256 | 99.9 |
| carex | 1 | 0.0 | 2257 | 100.0 |
| trpe4 | 1 | 0.0 | 2258 | 100.0 |

Appendix C -3. Frequency of occurrence of species found on 40 replications of Scott soil, Rainwater Basin.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| brin2 | 338 | 16.5 | 338 | 16.5 |
| amar2 | 324 | 15.8 | 662 | 32.3 |
| gramin | 320 | 15.6 | 982 | 48.0 |
| agst2 | 188 | 9.2 | 1170 | 57.2 |
| hoju | 117 | 5.7 | 1287 | 62.9 |
| pone | 106 | 5.2 | 1393 | 68.1 |
| poam8 | 82 | 4.0 | 1475 | 72.1 |
| elpa3 | 77 | 3.8 | 1552 | 75.8 |
| phar3 | 53 | 2.6 | 1605 | 78.4 |
| lopu3 | 51 | 2.5 | 1656 | 80.9 |
| pavi2 | 48 | 2.3 | 1704 | 83.2 |
| lase | 45 | 2.2 | 1749 | 85.4 |
| cala30 | 44 | 2.1 | 1793 | 87.6 |
| coca5 | 44 | 2.1 | 1837 | 89.7 |
| uf | 44 | 2.1 | 1881 | 91.9 |
| oxco | 19 | 0.9 | 1900 | 92.8 |
| compos | 18 | 0.9 | 1918 | 93.7 |
| pola4 | 18 | 0.9 | 1936 | 94.6 |
| cimu | 15 | 0.7 | 1951 | 95.3 |
| solid | 13 | 0.6 | 1964 | 95.9 |
| ciun | 10 | 0.5 | 1974 | 96.4 |
| arcal3 | 9 | 0.4 | 1983 | 96.9 |
| apsi | 8 | 0.4 | 1991 | 97.3 |
| cibu | 8 | 0.4 | 1999 | 97.7 |
| teca3 | 7 | 0.3 | 2006 | 98.0 |
| gaap2 | 6 | 0.3 | 2012 | 98.3 |
| lela2 | 5 | 0.2 | 2017 | 98.5 |
| rucr | 5 | 0.2 | 2022 | 98.8 |
| asin | 3 | 0.1 | 2025 | 98.9 |
| carex | 3 | 0.1 | 2028 | 99.1 |
| elac | 3 | 0.1 | 2031 | 99.2 |
| amre | 2 | 0.1 | 2033 | 99.3 |
| cirsi | 2 | 0.1 | 2035 | 99.4 |
| rubr | 2 | 0.1 | 2037 | 99.5 |
| apca | 1 | 0.0 | 2038 | 99.6 |
| aster | 1 | 0.0 | 2039 | 99.6 |
| caau3 | 1 | 0.0 | 2040 | 99.7 |
| cascl1 | 1 | 0.0 | 2041 | 99.7 |
| cavu2 | 1 | 0.0 | 2042 | 99.8 |
| cevu | 1 | 0.0 | 2043 | 99.8 |
| drau | 1 | 0.0 | 2044 | 99.9 |
| juin | 1 | 0.0 | 2045 | 99.9 |
| sian2 | 1 | 0.0 | 2046 | 100.0 |
| trpe4 | 1 | 0.0 | 2047 | 100.0 |

Appendix C-4. Frequency of occurrence of species found on 38 replications of Butler soil, Rainwater Basin.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| brin2 | 510 | 28.2 | 510 | 28.2 |
| poam8 | 212 | 11.7 | 722 | 39.9 |
| pone | 205 | 11.3 | 927 | 51.3 |
| pavi2 | 192 | 10.6 | 1119 | 61.9 |
| amar2 | 115 | 6.4 | 1234 | 68.3 |
| gramin | 89 | 4.9 | 1323 | 73.2 |
| lase | 84 | 4.6 | 1407 | 77.8 |
| gaap2 | 72 | 4.0 | 1479 | 81.8 |
| agst2 | 52 | 2.9 | 1531 | 84.7 |
| cimu | 36 | 2.0 | 1567 | 86.7 |
| ciun | 31 | 1.7 | 1598 | 88.4 |
| cala30 | 30 | 1.7 | 1628 | 90.0 |
| mear4 | 19 | 1.1 | 1647 | 91.1 |
| cirsi | 16 | 0.9 | 1663 | 92.0 |
| juin | 14 | 0.8 | 1677 | 92.8 |
| ipomo | 13 | 0.7 | 1690 | 93.5 |
| asin | 12 | 0.7 | 1702 | 94.1 |
| compos | 11 | 0.6 | 1713 | 94.7 |
| oxco | 11 | 0.6 | 1724 | 95.4 |
| rucr | 11 | 0.6 | 1735 | 96.0 |
| uf | 10 | 0.6 | 1745 | 96.5 |
| hoju | 9 | 0.5 | 1754 | 97.0 |
| trpe4 | 8 | 0.4 | 1762 | 97.5 |
| calal4 | 6 | 0.3 | 1768 | 97.8 |
| erst3 | 6 | 0.3 | 1774 | 98.1 |
| phar3 | 6 | 0.3 | 1780 | 98.5 |
| coca5 | 5 | 0.3 | 1785 | 98.7 |
| acmi2 | 4 | 0.2 | 1789 | 98.9 |
| apca | 3 | 0.2 | 1792 | 99.1 |
| apsi | 3 | 0.2 | 1795 | 99.3 |
| cibu | 3 | 0.2 | 1798 | 99.4 |
| lopu3 | 3 | 0.2 | 1801 | 99.6 |
| solid | 3 | 0.2 | 1804 | 99.8 |
| teca3 | 2 | 0.1 | 1806 | 99.9 |
| cevu | 1 | 0.1 | 1807 | 99.9 |
| pape5 | 1 | 0.1 | 1808 | 100.0 |

Appendix C-5. Frequency of occurrence of species found on 40 replications of Marlake soil, Rock County.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| utma | 360 | 17.8 | 360 | 17.8 |
| lemi3 | 260 | 12.9 | 620 | 30.7 |
| letr | 181 | 9.0 | 801 | 39.7 |
| scfl | 143 | 7.1 | 944 | 46.7 |
| elpa3 | 130 | 6.4 | 1074 | 53.2 |
| cavu2 | 121 | 6.0 | 1195 | 59.2 |
| tyla | 120 | 5.9 | 1315 | 65.1 |
| caat2 | 103 | 5.1 | 1418 | 70.2 |
| sagit | 91 | 4.5 | 1509 | 74.7 |
| cala30 | 84 | 4.2 | 1593 | 78.9 |
| cain | 61 | 3.0 | 1654 | 81.9 |
| caal8 | 58 | 2.9 | 1712 | 84.8 |
| poam8 | 56 | 2.8 | 1768 | 87.5 |
| poa | 50 | 2.5 | 1818 | 90.0 |
| ascle | 35 | 1.7 | 1853 | 91.7 |
| gramin | 33 | 1.6 | 1886 | 93.4 |
| sppo | 33 | 1.6 | 1919 | 95.0 |
| tyan | 16 | 0.8 | 1935 | 95.8 |
| calal4 | 15 | 0.7 | 1950 | 96.5 |
| pohy2 | 15 | 0.7 | 1965 | 97.3 |
| carex | 13 | 0.6 | 1978 | 97.9 |
| caca4 | 12 | 0.6 | 1990 | 98.5 |
| phar3 | 8 | 0.4 | 1998 | 98.9 |
| speu | 8 | 0.4 | 2006 | 99.3 |
| deve | 4 | 0.2 | 2010 | 99.5 |
| coca5 | 2 | 0.1 | 2012 | 99.6 |
| rumex | 2 | 0.1 | 2014 | 99.7 |
| cima2 | 1 | 0.0 | 2015 | 99.8 |
| eleoc | 1 | 0.0 | 2016 | 99.8 |
| galiu | 1 | 0.0 | 2017 | 99.9 |
| ranunc | 1 | 0.0 | 2018 | 99.9 |
| rucr | 1 | 0.0 | 2019 | 100.0 |
| uf | 1 | 0.0 | 2020 | 100.0 |

Appendix C-6. Frequency of occurrence of species on 40 replications of Loup soil, Rock County.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| cast6 | 350 | 15.4 | 350 | 15.4 |
| elpa3 | 331 | 14.5 | 681 | 29.9 |
| trpr2 | 249 | 10.9 | 930 | 40.9 |
| agst2 | 176 | 7.7 | 1106 | 48.6 |
| hoju | 155 | 6.8 | 1261 | 55.4 |
| cala30 | 104 | 4.6 | 1365 | 60.0 |
| cavu2 | 97 | 4.3 | 1462 | 64.3 |
| teca3 | 94 | 4.1 | 1556 | 68.4 |
| poa | 81 | 3.6 | 1637 | 72.0 |
| scam2 | 63 | 2.8 | 1700 | 74.7 |
| poco | 48 | 2.1 | 1748 | 76.8 |
| amar2 | 42 | 1.8 | 1790 | 78.7 |
| caal8 | 42 | 1.8 | 1832 | 80.5 |
| phpr3 | 39 | 1.7 | 1871 | 82.2 |
| carex | 32 | 1.4 | 1903 | 83.6 |
| popr | 31 | 1.4 | 1934 | 85.0 |
| phar3 | 28 | 1.2 | 1962 | 86.2 |
| cascl1 | 25 | 1.1 | 1987 | 87.3 |
| poam8 | 24 | 1.1 | 2011 | 88.4 |
| cain11 | 21 | 0.9 | 2032 | 89.3 |
| gramin | 19 | 0.8 | 2051 | 90.2 |
| juin | 19 | 0.8 | 2070 | 91.0 |
| plpa2 | 18 | 0.8 | 2088 | 91.8 |
| brin2 | 16 | 0.7 | 2104 | 92.5 |
| lase | 16 | 0.7 | 2120 | 93.2 |
| compos | 14 | 0.6 | 2134 | 93.8 |
| drepa | 13 | 0.6 | 2147 | 94.4 |
| pohy2 | 12 | 0.5 | 2159 | 94.9 |
| trpr3 | 11 | 0.5 | 2170 | 95.4 |
| agex | 10 | 0.4 | 2180 | 95.8 |
| apsi | 9 | 0.4 | 2189 | 96.2 |
| uf | 9 | 0.4 | 2198 | 96.6 |
| solid | 8 | 0.4 | 2206 | 97.0 |
| caha7 | 6 | 0.3 | 2212 | 97.2 |
| cato3 | 6 | 0.3 | 2218 | 97.5 |
| gaob | 5 | 0.2 | 2223 | 97.7 |
| rumex | 5 | 0.2 | 2228 | 97.9 |
| juba | 4 | 0.2 | 2232 | 98.1 |
| mear4 | 4 | 0.2 | 2236 | 98.3 |
| padi2 | 4 | 0.2 | 2240 | 98.5 |
| rucr | 4 | 0.2 | 2244 | 98.6 |
| cast8 | 3 | 0.1 | 2247 | 98.8 |
| eleoc | 3 | 0.1 | 2250 | 98.9 |
| eqfl | 3 | 0.1 | 2253 | 99.0 |
| meal2 | 3 | 0.1 | 2256 | 99.2 |
| veron | 3 | 0.1 | 2259 | 99.3 |

| | | | | |
|---|---|---|---|---|
| acmi2 | 2 | 0.1 | 2261 | 99.4 |
| ruve3 | 2 | 0.1 | 2263 | 99.5 |
| soca6 | 2 | 0.1 | 2265 | 99.6 |
| hyca7 | 1 | 0.0 | 2266 | 99.6 |
| juncu | 1 | 0.0 | 2267 | 99.6 |
| lactu | 1 | 0.0 | 2268 | 99.7 |
| lemi3 | 1 | 0.0 | 2269 | 99.7 |
| oxco | 1 | 0.0 | 2270 | 99.8 |
| phan5 | 1 | 0.0 | 2271 | 99.8 |
| pola4 | 1 | 0.0 | 2272 | 99.9 |
| pope2 | 1 | 0.0 | 2273 | 99.9 |
| sppo | 1 | 0.0 | 2274 | 100.0 |
| veba | 1 | 0.0 | 2275 | 100.0 |

Appendix C-7. Frequency of occurrence of species found on 40 replications of Tryon soil, Rock County.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| cast6 | 387 | 16.7 | 387 | 16.7 |
| eragr | 341 | 14.7 | 728 | 31.4 |
| trpr2 | 148 | 6.4 | 876 | 37.8 |
| agex | 119 | 5.1 | 995 | 42.9 |
| brja | 117 | 5.0 | 1112 | 48.0 |
| elpa3 | 111 | 4.8 | 1223 | 52.8 |
| phpr3 | 110 | 4.7 | 1333 | 57.5 |
| cala30 | 108 | 4.7 | 1441 | 62.2 |
| poa | 63 | 2.7 | 1504 | 64.9 |
| caal8 | 52 | 2.2 | 1556 | 67.1 |
| agst2 | 50 | 2.2 | 1606 | 69.3 |
| agros | 48 | 2.1 | 1654 | 71.4 |
| phar3 | 48 | 2.1 | 1702 | 73.4 |
| gramin | 45 | 1.9 | 1747 | 75.4 |
| caha7 | 44 | 1.9 | 1791 | 77.3 |
| hoju | 42 | 1.8 | 1833 | 79.1 |
| juin | 42 | 1.8 | 1875 | 80.9 |
| carex | 39 | 1.7 | 1914 | 82.6 |
| teca3 | 38 | 1.6 | 1952 | 84.2 |
| lase | 24 | 1.0 | 1976 | 85.2 |
| eqfl | 21 | 0.9 | 1997 | 86.2 |
| acmi2 | 19 | 0.8 | 2016 | 87.0 |
| brte | 19 | 0.8 | 2035 | 87.8 |
| cato3 | 19 | 0.8 | 2054 | 88.6 |
| padi2 | 18 | 0.8 | 2072 | 89.4 |
| uf | 16 | 0.7 | 2088 | 90.1 |
| assp | 15 | 0.6 | 2103 | 90.7 |
| poam8 | 15 | 0.6 | 2118 | 91.4 |
| pohy2 | 15 | 0.6 | 2133 | 92.0 |
| juncu | 14 | 0.6 | 2147 | 92.6 |
| oxco | 12 | 0.5 | 2159 | 93.1 |
| plpa2 | 12 | 0.5 | 2171 | 93.7 |
| juba | 11 | 0.5 | 2182 | 94.1 |
| sian2 | 10 | 0.4 | 2192 | 94.6 |
| solid | 9 | 0.4 | 2201 | 95.0 |
| drepa | 8 | 0.3 | 2209 | 95.3 |
| cavu2 | 7 | 0.3 | 2216 | 95.6 |
| eleoc | 7 | 0.3 | 2223 | 95.9 |
| ipomo | 7 | 0.3 | 2230 | 96.2 |
| meal2 | 7 | 0.3 | 2237 | 96.5 |
| scfl | 7 | 0.3 | 2244 | 96.8 |
| amar2 | 6 | 0.3 | 2250 | 97.1 |
| cate3 | 6 | 0.3 | 2256 | 97.3 |
| phan5 | 6 | 0.3 | 2262 | 97.6 |
| rucr | 6 | 0.3 | 2268 | 97.8 |
| viola | 6 | 0.3 | 2274 | 98.1 |

| | | | | |
|---|---|---|---|---|
| scam2 | 5 | 0.2 | 2279 | 98.3 |
| eqpa | 4 | 0.2 | 2283 | 98.5 |
| lemi3 | 4 | 0.2 | 2287 | 98.7 |
| apca | 3 | 0.1 | 2290 | 98.8 |
| galiu | 3 | 0.1 | 2293 | 98.9 |
| trpr3 | 3 | 0.1 | 2296 | 99.1 |
| apsi | 2 | 0.1 | 2298 | 99.1 |
| ascle | 2 | 0.1 | 2300 | 99.2 |
| eqla | 2 | 0.1 | 2302 | 99.3 |
| pola4 | 2 | 0.1 | 2304 | 99.4 |
| sagit | 2 | 0.1 | 2306 | 99.5 |
| sppe | 2 | 0.1 | 2308 | 99.6 |
| coca5 | 1 | 0.0 | 2309 | 99.6 |
| cypera | 1 | 0.0 | 2310 | 99.7 |
| elco2 | 1 | 0.0 | 2311 | 99.7 |
| erph | 1 | 0.0 | 2312 | 99.7 |
| mear4 | 1 | 0.0 | 2313 | 99.8 |
| opvu | 1 | 0.0 | 2314 | 99.8 |
| pasc5 | 1 | 0.0 | 2315 | 99.9 |
| phco | 1 | 0.0 | 2316 | 99.9 |
| rosi | 1 | 0.0 | 2317 | 100.0 |
| trdu | 1 | 0.0 | 2318 | 100.0 |

Appendix C-8. Frequency of occurrence of species found on 40 replications of Marlake soil, Valentine National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| cala30 | 295 | 16.3 | 295 | 16.3 |
| utma | 266 | 14.7 | 561 | 30.9 |
| elpa3 | 228 | 12.6 | 789 | 43.5 |
| caal8 | 180 | 9.9 | 969 | 53.4 |
| phar3 | 180 | 9.9 | 1149 | 63.3 |
| drepa | 155 | 8.5 | 1304 | 71.8 |
| caat2 | 90 | 5.0 | 1394 | 76.8 |
| sagit | 88 | 4.8 | 1482 | 81.7 |
| deve | 70 | 3.9 | 1552 | 85.5 |
| poam8 | 47 | 2.6 | 1599 | 88.1 |
| tyla | 37 | 2.0 | 1636 | 90.1 |
| cast6 | 23 | 1.3 | 1659 | 91.4 |
| carex | 22 | 1.2 | 1681 | 92.6 |
| caha7 | 19 | 1.0 | 1700 | 93.7 |
| lemi3 | 18 | 1.0 | 1718 | 94.7 |
| agst2 | 16 | 0.9 | 1734 | 95.5 |
| sppo | 15 | 0.8 | 1749 | 96.4 |
| scga | 11 | 0.6 | 1760 | 97.0 |
| gaob | 8 | 0.4 | 1768 | 97.4 |
| sppe | 8 | 0.4 | 1776 | 97.9 |
| juba | 7 | 0.4 | 1783 | 98.2 |
| rifl | 5 | 0.3 | 1788 | 98.5 |
| rumex | 4 | 0.2 | 1792 | 98.7 |
| cainll | 3 | 0.2 | 1795 | 98.9 |
| letr | 3 | 0.2 | 1798 | 99.1 |
| speu | 3 | 0.2 | 1801 | 99.2 |
| veron | 3 | 0.2 | 1804 | 99.4 |
| cavu2 | 2 | 0.1 | 1806 | 99.5 |
| cima2 | 2 | 0.1 | 1808 | 99.6 |
| mear4 | 2 | 0.1 | 1810 | 99.7 |
| adpe | 1 | 0.1 | 1811 | 99.8 |
| asin | 1 | 0.1 | 1812 | 99.8 |
| polyg | 1 | 0.1 | 1813 | 99.9 |
| spga | 1 | 0.1 | 1814 | 99.9 |
| uf | 1 | 0.1 | 1815 | 100.0 |

Appendix C-9. Frequency of occurrence of species found on 40 replications of Tryon soil, Valentine National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| agst2 | 289 | 15.3 | 289 | 15.3 |
| phpr3 | 216 | 11.4 | 505 | 26.7 |
| cala30 | 202 | 10.7 | 707 | 37.3 |
| popr | 160 | 8.4 | 867 | 45.8 |
| trpr2 | 127 | 6.7 | 994 | 52.5 |
| phar3 | 123 | 6.5 | 1117 | 59.0 |
| juba | 89 | 4.7 | 1206 | 63.7 |
| cast6 | 75 | 4.0 | 1281 | 67.6 |
| elpa3 | 75 | 4.0 | 1356 | 71.6 |
| acmi2 | 71 | 3.7 | 1427 | 75.3 |
| trpr3 | 51 | 2.7 | 1478 | 78.0 |
| poal3 | 42 | 2.2 | 1520 | 80.3 |
| caal8 | 39 | 2.1 | 1559 | 82.3 |
| pasc5 | 32 | 1.7 | 1591 | 84.0 |
| carex | 30 | 1.6 | 1621 | 85.6 |
| juin | 27 | 1.4 | 1648 | 87.0 |
| eqfl | 25 | 1.3 | 1673 | 88.3 |
| cascl1 | 24 | 1.3 | 1697 | 89.6 |
| drepa | 20 | 1.1 | 1717 | 90.7 |
| cain11 | 17 | 0.9 | 1734 | 91.6 |
| sppe | 15 | 0.8 | 1749 | 92.3 |
| eleoc | 13 | 0.7 | 1762 | 93.0 |
| cavu2 | 12 | 0.6 | 1774 | 93.7 |
| brin2 | 10 | 0.5 | 1784 | 94.2 |
| cato3 | 9 | 0.5 | 1793 | 94.7 |
| erst3 | 6 | 0.3 | 1799 | 95.0 |
| eula | 6 | 0.3 | 1805 | 95.3 |
| oxco | 6 | 0.3 | 1811 | 95.6 |
| sogi | 6 | 0.3 | 1817 | 95.9 |
| amar2 | 5 | 0.3 | 1822 | 96.2 |
| arcal3 | 5 | 0.3 | 1827 | 96.5 |
| ascle | 5 | 0.3 | 1832 | 96.7 |
| caha7 | 5 | 0.3 | 1837 | 97.0 |
| laca | 5 | 0.3 | 1842 | 97.3 |
| lase | 5 | 0.3 | 1847 | 97.5 |
| anne | 4 | 0.2 | 1851 | 97.7 |
| daen | 4 | 0.2 | 1855 | 97.9 |
| meal2 | 4 | 0.2 | 1859 | 98.2 |
| popal5 | 4 | 0.2 | 1863 | 98.4 |
| ruac3 | 4 | 0.2 | 1867 | 98.6 |
| heri2 | 3 | 0.2 | 1870 | 98.7 |
| hyhi2 | 3 | 0.2 | 1873 | 98.9 |
| pavi2 | 3 | 0.2 | 1876 | 99.0 |
| taof | 3 | 0.2 | 1879 | 99.2 |
| agtr | 2 | 0.1 | 1881 | 99.3 |
| soca6 | 2 | 0.1 | 1883 | 99.4 |

| | | | | |
|---|---|---|---|---|
| uf | 2 | 0.1 | 1885 | 99.5 |
| viola | 2 | 0.1 | 1887 | 99.6 |
| aser3 | 1 | 0.1 | 1888 | 99.7 |
| juncu | 1 | 0.1 | 1889 | 99.7 |
| lactu | 1 | 0.1 | 1890 | 99.8 |
| lopu3 | 1 | 0.1 | 1891 | 99.8 |
| plpa2 | 1 | 0.1 | 1892 | 99.9 |
| ruhi2 | 1 | 0.1 | 1893 | 99.9 |
| teca3 | 1 | 0.1 | 1894 | 100.0 |

Appendix C-10. Frequency of occurrence of species found on 30 replications of Els soil, Valentine National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| popr | 203 | 14.2 | 203 | 14.2 |
| agst2 | 178 | 12.4 | 381 | 26.6 |
| acmi2 | 175 | 12.2 | 556 | 38.8 |
| pavi2 | 140 | 9.8 | 696 | 48.5 |
| trpr2 | 112 | 7.8 | 808 | 56.3 |
| pasc5 | 105 | 7.3 | 913 | 63.7 |
| phpr3 | 91 | 6.3 | 1004 | 70.0 |
| arcal3 | 71 | 5.0 | 1075 | 75.0 |
| cala30 | 67 | 4.7 | 1142 | 79.6 |
| eqfl | 56 | 3.9 | 1198 | 83.5 |
| lapo2 | 31 | 2.2 | 1229 | 85.7 |
| phar3 | 30 | 2.1 | 1259 | 87.8 |
| juba | 23 | 1.6 | 1282 | 89.4 |
| elpa3 | 22 | 1.5 | 1304 | 90.9 |
| amar2 | 13 | 0.9 | 1317 | 91.8 |
| juin | 12 | 0.8 | 1329 | 92.7 |
| trdu | 12 | 0.8 | 1341 | 93.5 |
| carex | 10 | 0.7 | 1351 | 94.2 |
| trpr3 | 10 | 0.7 | 1361 | 94.9 |
| uf | 9 | 0.6 | 1370 | 95.5 |
| kopy | 8 | 0.6 | 1378 | 96.1 |
| cast6 | 6 | 0.4 | 1384 | 96.5 |
| cato3 | 5 | 0.3 | 1389 | 96.9 |
| ecan2 | 4 | 0.3 | 1393 | 97.1 |
| oxco | 4 | 0.3 | 1397 | 97.4 |
| raco3 | 4 | 0.3 | 1401 | 97.7 |
| amca6 | 3 | 0.2 | 1404 | 97.9 |
| anne | 3 | 0.2 | 1407 | 98.1 |
| erst3 | 3 | 0.2 | 1410 | 98.3 |
| heri2 | 3 | 0.2 | 1413 | 98.5 |
| psar2 | 3 | 0.2 | 1416 | 98.7 |
| fabace | 2 | 0.1 | 1418 | 98.9 |
| laca | 2 | 0.1 | 1420 | 99.0 |
| phhe5 | 2 | 0.1 | 1422 | 99.2 |
| sian2 | 2 | 0.1 | 1424 | 99.3 |
| sogi | 2 | 0.1 | 1426 | 99.4 |
| ascle | 1 | 0.1 | 1427 | 99.5 |
| brja | 1 | 0.1 | 1428 | 99.6 |
| hyhi2 | 1 | 0.1 | 1429 | 99.7 |
| lase | 1 | 0.1 | 1430 | 99.7 |
| popal5 | 1 | 0.1 | 1431 | 99.8 |
| ruhi2 | 1 | 0.1 | 1432 | 99.9 |
| rumex | 1 | 0.1 | 1433 | 99.9 |
| viola | 1 | 0.1 | 1434 | 100.0 |

Appendix C -11. Frequency of occurrence of species found on 10 replications of Ipage soil, Valentine National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| popr | 107 | 18.9 | 107 | 18.9 |
| trpr2 | 72 | 12.7 | 179 | 31.7 |
| acmi2 | 69 | 12.2 | 248 | 43.9 |
| cainl1 | 36 | 6.4 | 284 | 50.3 |
| pasc5 | 36 | 6.4 | 320 | 56.6 |
| pavi2 | 28 | 5.0 | 348 | 61.6 |
| psar2 | 28 | 5.0 | 376 | 66.5 |
| agst2 | 26 | 4.6 | 402 | 71.2 |
| lapo2 | 25 | 4.4 | 427 | 75.6 |
| phpr3 | 22 | 3.9 | 449 | 79.5 |
| arcal3 | 19 | 3.4 | 468 | 82.8 |
| eqfl | 13 | 2.3 | 481 | 85.1 |
| trdu | 12 | 2.1 | 493 | 87.3 |
| gramin | 10 | 1.8 | 503 | 89.0 |
| oxco | 9 | 1.6 | 512 | 90.6 |
| trpr3 | 9 | 1.6 | 521 | 92.2 |
| civu | 8 | 1.4 | 529 | 93.6 |
| juba | 6 | 1.1 | 535 | 94.7 |
| agcr | 4 | 0.7 | 539 | 95.4 |
| amps | 3 | 0.5 | 542 | 95.9 |
| anne | 3 | 0.5 | 545 | 96.5 |
| cascl1 | 3 | 0.5 | 548 | 97.0 |
| erst3 | 3 | 0.5 | 551 | 97.5 |
| lase | 3 | 0.5 | 554 | 98.1 |
| carex | 2 | 0.4 | 556 | 98.4 |
| phar3 | 2 | 0.4 | 558 | 98.8 |
| taof | 2 | 0.4 | 560 | 99.1 |
| uf | 2 | 0.4 | 562 | 99.5 |
| cala30 | 1 | 0.2 | 563 | 99.6 |
| cirsi | 1 | 0.2 | 564 | 99.8 |
| juin | 1 | 0.2 | 565 | 100.0 |

Appendix C-12. Frequency of occurrence of species found on 109 replications of Marlake soil, Crescent Lake National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| algae | 448 | 13.6 | 448 | 13.6 |
| scto | 390 | 11.8 | 838 | 25.4 |
| poam8 | 328 | 10.0 | 1166 | 35.4 |
| tyla | 240 | 7.3 | 1406 | 42.7 |
| phar3 | 222 | 6.7 | 1628 | 49.4 |
| uf | 215 | 6.5 | 1843 | 55.9 |
| carex | 201 | 6.1 | 2044 | 62.0 |
| scac | 194 | 5.9 | 2238 | 67.9 |
| imca | 105 | 3.2 | 2343 | 71.1 |
| mear4 | 105 | 3.2 | 2448 | 74.3 |
| drepa | 69 | 2.1 | 2517 | 76.4 |
| hoju | 59 | 1.8 | 2576 | 78.2 |
| sppe | 58 | 1.8 | 2634 | 79.9 |
| caat2 | 50 | 1.5 | 2684 | 81.4 |
| cala30 | 49 | 1.5 | 2733 | 82.9 |
| speu | 48 | 1.5 | 2781 | 84.4 |
| scga | 39 | 1.2 | 2820 | 85.6 |
| sagit | 38 | 1.2 | 2858 | 86.7 |
| eleoc | 35 | 1.1 | 2893 | 87.8 |
| disp | 29 | 0.9 | 2922 | 88.7 |
| elpa3 | 28 | 0.8 | 2950 | 89.5 |
| ascle | 26 | 0.8 | 2976 | 90.3 |
| cavu2 | 25 | 0.8 | 3001 | 91.0 |
| agst2 | 22 | 0.7 | 3023 | 91.7 |
| cast6 | 22 | 0.7 | 3045 | 92.4 |
| deve | 22 | 0.7 | 3067 | 93.1 |
| chhy | 21 | 0.6 | 3088 | 93.7 |
| teca3 | 20 | 0.6 | 3108 | 94.3 |
| vefa2 | 20 | 0.6 | 3128 | 94.9 |
| urdi | 19 | 0.6 | 3147 | 95.5 |
| juin | 15 | 0.5 | 3162 | 95.9 |
| gaob | 12 | 0.4 | 3174 | 96.3 |
| hema2 | 12 | 0.4 | 3186 | 96.7 |
| trma4 | 12 | 0.4 | 3198 | 97.0 |
| scirp | 11 | 0.3 | 3209 | 97.4 |
| gatr2 | 10 | 0.3 | 3219 | 97.7 |
| oebi | 8 | 0.2 | 3227 | 97.9 |
| sogi | 7 | 0.2 | 3234 | 98.1 |
| cheno | 6 | 0.2 | 3240 | 98.3 |
| juncu | 6 | 0.2 | 3246 | 98.5 |
| amar2 | 5 | 0.2 | 3251 | 98.6 |
| amps | 5 | 0.2 | 3256 | 98.8 |
| losi | 5 | 0.2 | 3261 | 98.9 |
| rucr | 4 | 0.1 | 3265 | 99.1 |
| soca6 | 4 | 0.1 | 3269 | 99.2 |

| | | | | |
|---|---|---|---|---|
| alpl | 3 | 0.1 | 3272 | 99.3 |
| apsi | 3 | 0.1 | 3275 | 99.4 |
| elymu | 3 | 0.1 | 3278 | 99.5 |
| sian3 | 3 | 0.1 | 3281 | 99.5 |
| brja | 2 | 0.1 | 3283 | 99.6 |
| chvu | 2 | 0.1 | 3285 | 99.7 |
| cirsi | 2 | 0.1 | 3287 | 99.7 |
| gramin | 2 | 0.1 | 3289 | 99.8 |
| scro | 2 | 0.1 | 3291 | 99.8 |
| aster | 1 | 0.0 | 3292 | 99.9 |
| bifr | 1 | 0.0 | 3293 | 99.9 |
| phpr3 | 1 | 0.0 | 3294 | 99.9 |
| poten | 1 | 0.0 | 3295 | 100.0 |
| tate | 1 | 0.0 | 3296 | 100.0 |

Appendix C-13. Frequency of occurrence of species found on 40 replications of Hoffland soil, Crescent Lake National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| carex | 292 | 22.3 | 292 | 22.3 |
| phar3 | 122 | 9.3 | 414 | 31.6 |
| agst2 | 116 | 8.8 | 530 | 40.4 |
| gramin | 85 | 6.5 | 615 | 46.9 |
| popr | 69 | 5.3 | 684 | 52.1 |
| agtr | 65 | 5.0 | 749 | 57.1 |
| hoju | 64 | 4.9 | 813 | 62.0 |
| cala30 | 55 | 4.2 | 868 | 66.2 |
| poam8 | 46 | 3.5 | 914 | 69.7 |
| brja | 42 | 3.2 | 956 | 72.9 |
| soca6 | 38 | 2.9 | 994 | 75.8 |
| scto | 28 | 2.1 | 1022 | 77.9 |
| cainl1 | 26 | 2.0 | 1048 | 79.9 |
| ansc2 | 25 | 1.9 | 1073 | 81.8 |
| smst | 25 | 1.9 | 1098 | 83.7 |
| cavu2 | 24 | 1.8 | 1122 | 85.5 |
| juba | 21 | 1.6 | 1143 | 87.1 |
| sppe | 21 | 1.6 | 1164 | 88.7 |
| vefa2 | 20 | 1.5 | 1184 | 90.2 |
| juin | 16 | 1.2 | 1200 | 91.5 |
| teca3 | 13 | 1.0 | 1213 | 92.5 |
| civu | 11 | 0.8 | 1224 | 93.3 |
| cirsi | 10 | 0.8 | 1234 | 94.1 |
| juncu | 9 | 0.7 | 1243 | 94.7 |
| viola | 7 | 0.5 | 1250 | 95.3 |
| agre | 6 | 0.5 | 1256 | 95.7 |
| assp | 6 | 0.5 | 1262 | 96.2 |
| elpa3 | 6 | 0.5 | 1268 | 96.6 |
| trma4 | 6 | 0.5 | 1274 | 97.1 |
| plpa2 | 5 | 0.4 | 1279 | 97.5 |
| mear4 | 4 | 0.3 | 1283 | 97.8 |
| amar2 | 3 | 0.2 | 1286 | 98.0 |
| eqfl | 3 | 0.2 | 1289 | 98.2 |
| jute | 3 | 0.2 | 1292 | 98.5 |
| lase | 3 | 0.2 | 1295 | 98.7 |
| meal2 | 2 | 0.2 | 1297 | 98.9 |
| rucr | 2 | 0.2 | 1299 | 99.0 |
| ruhi2 | 2 | 0.2 | 1301 | 99.2 |
| scga | 2 | 0.2 | 1303 | 99.3 |
| stco4 | 2 | 0.2 | 1305 | 99.5 |
| uf | 2 | 0.2 | 1307 | 99.6 |
| chru | 1 | 0.1 | 1308 | 99.7 |
| coca5 | 1 | 0.1 | 1309 | 99.8 |
| scirp | 1 | 0.1 | 1310 | 99.8 |
| tate | 1 | 0.1 | 1311 | 99.9 |
| trpr3 | 1 | 0.1 | 1312 | 100.0 |

Appendix C-14. Frequency of occurrence of species found on 40 replications of Loup soil, Crescent Lake National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| carex | 160 | 16.4 | 160 | 16.4 |
| poam8 | 153 | 15.7 | 313 | 32.1 |
| phar3 | 110 | 11.3 | 423 | 43.3 |
| vefa2 | 69 | 7.1 | 492 | 50.4 |
| juncu | 62 | 6.4 | 554 | 56.8 |
| soca6 | 53 | 5.4 | 607 | 62.2 |
| popr | 41 | 4.2 | 648 | 66.4 |
| pavi2 | 32 | 3.3 | 680 | 69.7 |
| urdi | 31 | 3.2 | 711 | 72.8 |
| lopu3 | 29 | 3.0 | 740 | 75.8 |
| juin | 27 | 2.8 | 767 | 78.6 |
| assp | 23 | 2.4 | 790 | 80.9 |
| caar3 | 22 | 2.3 | 812 | 83.2 |
| civu | 19 | 1.9 | 831 | 85.1 |
| amps | 14 | 1.4 | 845 | 86.6 |
| teca3 | 14 | 1.4 | 859 | 88.0 |
| ecsp | 12 | 1.2 | 871 | 89.2 |
| mear4 | 12 | 1.2 | 883 | 90.5 |
| deve | 11 | 1.1 | 894 | 91.6 |
| agre | 9 | 0.9 | 903 | 92.5 |
| agst2 | 8 | 0.8 | 911 | 93.3 |
| cirsi | 7 | 0.7 | 918 | 94.1 |
| juba | 6 | 0.6 | 924 | 94.7 |
| oenot | 6 | 0.6 | 930 | 95.3 |
| poco | 6 | 0.6 | 936 | 95.9 |
| uf | 5 | 0.5 | 941 | 96.4 |
| veba | 5 | 0.5 | 946 | 96.9 |
| sori | 4 | 0.4 | 950 | 97.3 |
| chru | 3 | 0.3 | 953 | 97.6 |
| cima2 | 3 | 0.3 | 956 | 98.0 |
| gatr2 | 3 | 0.3 | 959 | 98.3 |
| ruhi2 | 3 | 0.3 | 962 | 98.6 |
| agsm | 2 | 0.2 | 964 | 98.8 |
| coca5 | 2 | 0.2 | 966 | 99.0 |
| agtr | 1 | 0.1 | 967 | 99.1 |
| apca | 1 | 0.1 | 968 | 99.2 |
| apsi | 1 | 0.1 | 969 | 99.3 |
| erph | 1 | 0.1 | 970 | 99.4 |
| heri2 | 1 | 0.1 | 971 | 99.5 |
| lyci | 1 | 0.1 | 972 | 99.6 |
| lyhy | 1 | 0.1 | 973 | 99.7 |
| poten | 1 | 0.1 | 974 | 99.8 |
| scga | 1 | 0.1 | 975 | 99.9 |
| trma4 | 1 | 0.1 | 976 | 100.0 |

Appendix C-15. Frequency of occurrence of species found on 40 replications of Tryon soil, Crescent Lake National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| phar3 | 164 | 15.7 | 164 | 15.7 |
| agsm | 154 | 14.7 | 318 | 30.4 |
| trpr3 | 114 | 10.9 | 432 | 41.3 |
| agre | 110 | 10.5 | 542 | 51.9 |
| popr | 88 | 8.4 | 630 | 60.3 |
| elca4 | 54 | 5.2 | 684 | 65.5 |
| sonu2 | 48 | 4.6 | 732 | 70.0 |
| agst2 | 35 | 3.3 | 767 | 73.4 |
| carex | 34 | 3.3 | 801 | 76.7 |
| brin2 | 32 | 3.1 | 833 | 79.7 |
| veba | 25 | 2.4 | 858 | 82.1 |
| brja | 23 | 2.2 | 881 | 84.3 |
| juin | 18 | 1.7 | 899 | 86.0 |
| lopu3 | 18 | 1.7 | 917 | 87.8 |
| pavi2 | 18 | 1.7 | 935 | 89.5 |
| poco | 16 | 1.5 | 951 | 91.0 |
| phpr3 | 12 | 1.1 | 963 | 92.2 |
| lase | 10 | 1.0 | 973 | 93.1 |
| agex | 9 | 0.9 | 982 | 94.0 |
| hema | 8 | 0.8 | 990 | 94.7 |
| rucr | 7 | 0.7 | 997 | 95.4 |
| cain11 | 6 | 0.6 | 1003 | 96.0 |
| coca5 | 6 | 0.6 | 1009 | 96.6 |
| meli1 | 6 | 0.6 | 1015 | 97.1 |
| cha17 | 4 | 0.4 | 1019 | 97.5 |
| trpr2 | 4 | 0.4 | 1023 | 97.9 |
| ansc2 | 3 | 0.3 | 1026 | 98.2 |
| oenot | 3 | 0.3 | 1029 | 98.5 |
| eqf1 | 2 | 0.2 | 1031 | 98.7 |
| juncu | 2 | 0.2 | 1033 | 98.9 |
| mea12 | 2 | 0.2 | 1035 | 99.0 |
| uf | 2 | 0.2 | 1037 | 99.2 |
| amps | 1 | 0.1 | 1038 | 99.3 |
| eleoc | 1 | 0.1 | 1039 | 99.4 |
| fabace | 1 | 0.1 | 1040 | 99.5 |
| heri2 | 1 | 0.1 | 1041 | 99.6 |
| juba | 1 | 0.1 | 1042 | 99.7 |
| plpa2 | 1 | 0.1 | 1043 | 99.8 |
| sian2 | 1 | 0.1 | 1044 | 99.9 |
| stle6 | 1 | 0.1 | 1045 | 100.0 |

Appendix C -16. Frequency of occurrence of species found on 70 replications of Els soil, Crescent Lake National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| popr | 139 | 9.2 | 139 | 9.2 |
| agtr | 138 | 9.1 | 277 | 18.3 |
| stco4 | 103 | 6.8 | 380 | 25.1 |
| phar3 | 100 | 6.6 | 480 | 31.7 |
| pavi2 | 98 | 6.5 | 578 | 38.2 |
| brja | 89 | 5.9 | 667 | 44.1 |
| brte | 82 | 5.4 | 749 | 49.5 |
| meal2 | 67 | 4.4 | 816 | 53.9 |
| ansc2 | 66 | 4.4 | 882 | 58.3 |
| carex | 66 | 4.4 | 948 | 62.6 |
| elca4 | 61 | 4.0 | 1009 | 66.6 |
| tora2 | 58 | 3.8 | 1067 | 70.5 |
| amar2 | 56 | 3.7 | 1123 | 74.2 |
| arcal3 | 48 | 3.2 | 1171 | 77.3 |
| uf | 43 | 2.8 | 1214 | 80.2 |
| solan | 40 | 2.6 | 1254 | 82.8 |
| mede2 | 36 | 2.4 | 1290 | 85.2 |
| poam8 | 17 | 1.1 | 1307 | 86.3 |
| coca5 | 16 | 1.1 | 1323 | 87.4 |
| cainll | 15 | 1.0 | 1338 | 88.4 |
| gramin | 15 | 1.0 | 1353 | 89.4 |
| oenot | 14 | 0.9 | 1367 | 90.3 |
| juba | 13 | 0.9 | 1380 | 91.1 |
| plpa2 | 13 | 0.9 | 1393 | 92.0 |
| agsm | 8 | 0.5 | 1401 | 92.5 |
| iple | 8 | 0.5 | 1409 | 93.1 |
| agre | 7 | 0.5 | 1416 | 93.5 |
| arcal2 | 7 | 0.5 | 1423 | 94.0 |
| soca6 | 7 | 0.5 | 1430 | 94.5 |
| assp | 6 | 0.4 | 1436 | 94.8 |
| lase | 6 | 0.4 | 1442 | 95.2 |
| phhe5 | 6 | 0.4 | 1448 | 95.6 |
| apca | 5 | 0.3 | 1453 | 96.0 |
| eqfl | 5 | 0.3 | 1458 | 96.3 |
| juncu | 5 | 0.3 | 1463 | 96.6 |
| agst2 | 4 | 0.3 | 1467 | 96.9 |
| disp | 4 | 0.3 | 1471 | 97.2 |
| lapo2 | 4 | 0.3 | 1475 | 97.4 |
| xast | 4 | 0.3 | 1479 | 97.7 |
| cheno | 3 | 0.2 | 1482 | 97.9 |
| crucif | 3 | 0.2 | 1485 | 98.1 |
| helia | 3 | 0.2 | 1488 | 98.3 |
| hoju | 3 | 0.2 | 1491 | 98.5 |
| pler | 3 | 0.2 | 1494 | 98.7 |
| stsp2 | 3 | 0.2 | 1497 | 98.9 |
| vefa2 | 3 | 0.2 | 1500 | 99.1 |

Appendix C -17. Frequency of occurrence of species found on 40 replications of Valentine soil, Crescent Lake National Wildlife Refuge.

| SP | FREQUENCY | PERCENT | CUMULATIVE FREQUENCY | CUMULATIVE PERCENT |
|---|---|---|---|---|
| stvi4 | 143 | 24.0 | 143 | 24.0 |
| ansc2 | 65 | 10.9 | 208 | 34.9 |
| brja | 64 | 10.7 | 272 | 45.6 |
| popr | 61 | 10.2 | 333 | 55.9 |
| arcal2 | 50 | 8.4 | 383 | 64.3 |
| stco4 | 47 | 7.9 | 430 | 72.1 |
| arcal3 | 41 | 6.9 | 471 | 79.0 |
| yucca | 25 | 4.2 | 496 | 83.2 |
| soni | 20 | 3.4 | 516 | 86.6 |
| agtr | 14 | 2.3 | 530 | 88.9 |
| agre | 13 | 2.2 | 543 | 91.1 |
| comme | 11 | 1.8 | 554 | 93.0 |
| mede2 | 7 | 1.2 | 561 | 94.1 |
| assp | 5 | 0.8 | 566 | 95.0 |
| scsc | 5 | 0.8 | 571 | 95.8 |
| amar2 | 4 | 0.7 | 575 | 96.5 |
| lyju | 4 | 0.7 | 579 | 97.1 |
| coti3 | 3 | 0.5 | 582 | 97.7 |
| cyper | 2 | 0.3 | 584 | 98.0 |
| kosc | 2 | 0.3 | 586 | 98.3 |
| oenot | 2 | 0.3 | 588 | 98.7 |
| uf | 2 | 0.3 | 590 | 99.0 |
| cheno | 1 | 0.2 | 591 | 99.2 |
| eqfl | 1 | 0.2 | 592 | 99.3 |
| helia | 1 | 0.2 | 593 | 99.5 |
| heri2 | 1 | 0.2 | 594 | 99.7 |
| opim | 1 | 0.2 | 595 | 99.8 |
| polyg | 1 | 0.2 | 596 | 100.0 |

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

As part of a national study, vegetation associated with known hydric and nonhydric soil series was sampled in selected wetlands in the Rainwater Basin and Sandhills regions of Nebraska. Weighted averages, presence/absence averages, and Michener averages were calculated for vegetation in each soil series and individual wetlands within soil series, based on importance values and ecological indices assigned by the National Wetland Plant List. Eleven times out of twelve, hydric soils were designated as wetlands based on vegetation. One hydric soil in the Sandhills region supported a higher proportion of species adapted to non-wetland conditions. Four out of five samples of nonhydric soils supported a preponderance of upland species. Results obtained with weighted and presence/absence averages may be preferred over weighted averages because information concerning species dominance (e.g., percent cover) is not required. However, correct identification of all species is more critical with use of presence/absence averages.

17. Document Analysis a. Descriptors

wetland ecosystems
wetland soils
wetland vegetation
wetland ecology

b. Identifiers/Open-Ended Terms

Nebraska Sandhill wetland
Nebraska Rainwater basin wetland

c. COSATI Field/Group

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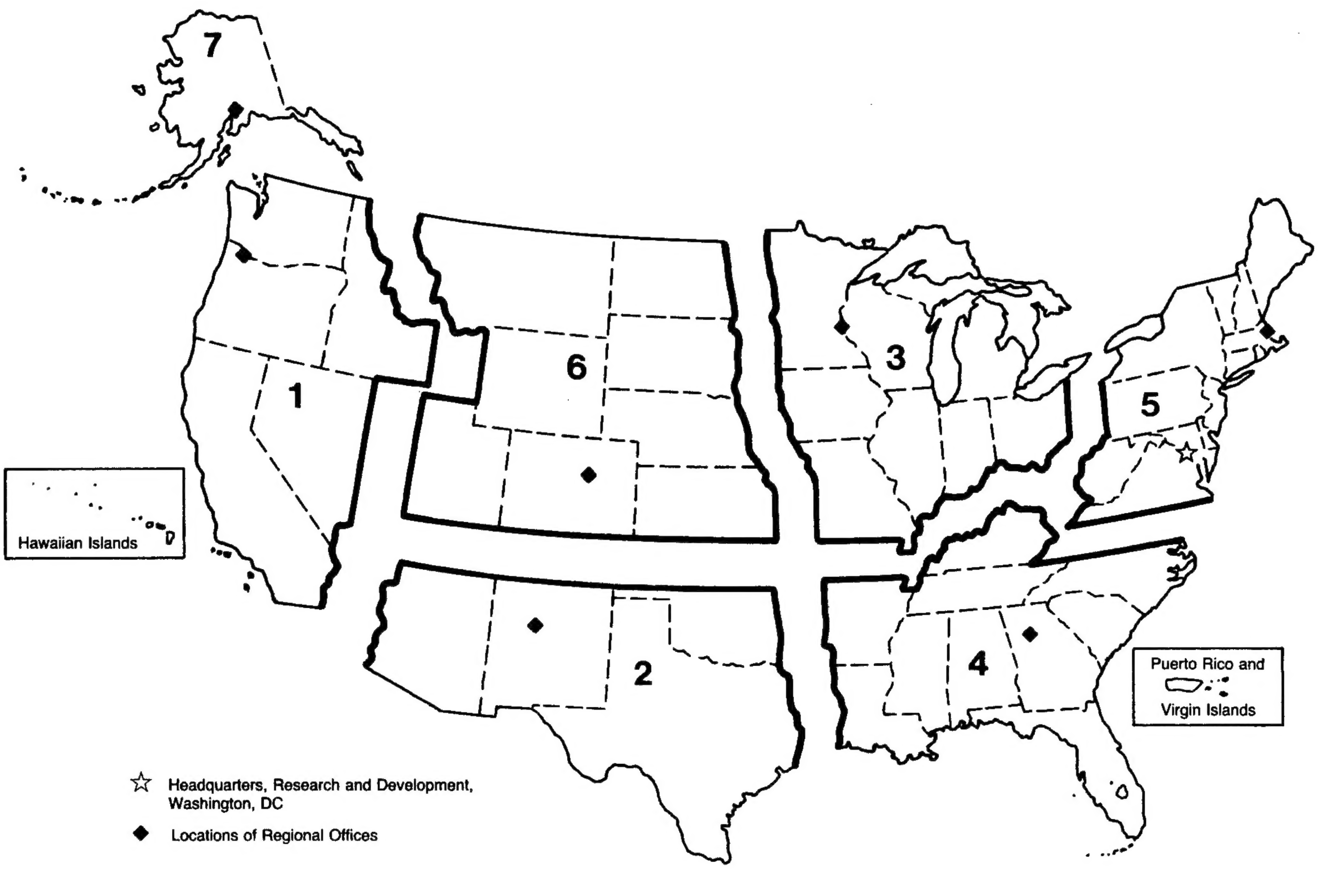


**REGION 1**
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

**REGION 2**
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

**REGION 3**
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

**REGION 4**
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

**REGION 5**
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

**REGION 6**
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

**REGION 7**
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

TAKE PRIDE IN AMERICA

*Preserve Our Natural Resources*

**DEPARTMENT OF THE INTERIOR**

**U.S. FISH AND WILDLIFE SERVICE**

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.